UCRL-ID-113867-96

Environmental Protection Department

Operations and Regulatory Affairs Division

LLNL NESHAPs
1995 Annual Report

Lawrence Livermore National Laboratory
University of California Livermore, California 94550

Work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract W–7405–Eng–48.

LLNL NESHAPs
1995 Annual Report

Gretchen M. Gallegos
Robert J. Harrach
Arthur H. Biermann
Paula J. Tate
Frank J. Gouveia
Barbara C. Fields
Kris A. Surano

Contributors:

P. Althouse
J. Kelly
J. White

U.S. Department of Energy
Radionuclide Air Emission Annual Report
(under Subpart H of 40 CFR Part 61)
Calendar Year 1995

Site Name: Lawrence Livermore National Laboratory

Operations Office Information

Office: Oakland Operations Office

Address: 1301 Clay Street
Oakland, CA 94612

Contact: Edward M. Ballard Phone: 510-423-3020

Site Information

Operator: University of California

Address: 7000 East Avenue
Livermore, CA 94550

Contact: C. Susi Jackson Phone: 510-423-6577

June 1996

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Lawrence Livermore National Laboratory 1995 NESHAPs Report

This annual report is prepared pursuant to the National Emissions Standards for Hazardous Air Pollutants (NESHAPs) 40 CFR Part 61, Subpart H; Subpart H governs radionuclide emissions to air from Department of Energy (DOE) facilities.

SYNOPSIS

NESHAPs limits the emission of radionuclides to the ambient air from DOE facilities to levels resulting in an annual effective dose equivalent (EDE) of 10 mrem (100 μSv) to any member of the public. The EDEs for the Lawrence Livermore National Laboratory (LLNL) site-wide maximally exposed members of the public from 1995 operations were

- Livermore site: 0.041 mrem (0.41 μSv) (46% from stack emissions, 54% from diffuse-source emissions);
- Site 300: 0.023 mrem (0.23 μSv) (87% due to emissions from explosives experiments, 13% from diffuse-source emissions).

The EDEs were generally calculated using the EPA-approved CAP88-PC air-dispersion/dose-assessment model. The inventory data or continuous-monitoring systems data, stack flow data, and site-specific meteorological data for each modeled source were the specific input to the CAP88-PC model.

SECTION I. Facilities Information

Site Description

The University of California operates LLNL for DOE. LLNL was established in 1952 to conduct weapons research and development. LLNL's current mission is to serve as a national resource in science and engineering, with a focus on national security, energy, the environment, biomedicine, economic competitiveness, and science and mathematics education. LLNL's mission is

dynamic and over the years has been broadened to meet new national needs. LLNL consists of two sites—the main laboratory site located in Livermore, California (Livermore site), and the Experimental Test Facility (Site 300) located near Tracy, California. Figure 1 shows the locations of the sites.

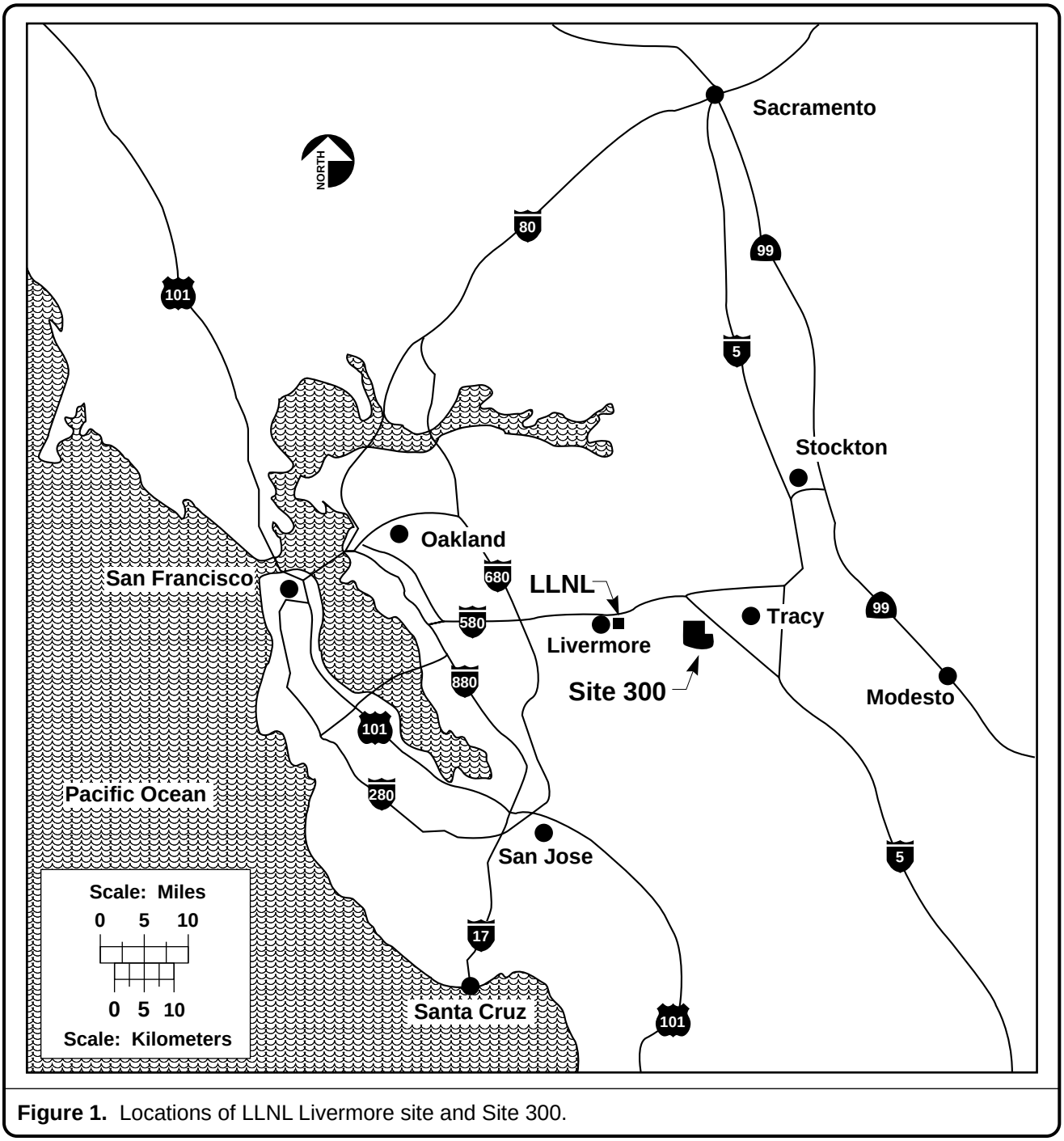

Figure 1. Locations of LLNL Livermore site and Site 300.

Livermore site: LLNL's Livermore site occupies an area of 3.3 km^2 located about 60 km east of San Francisco, California, adjacent to the City of Livermore in the eastern part of Alameda County. More than 6 million people live within 80 km of LLNL; approximately 65,000 of them live in the City of Livermore.

The Livermore site is located in the southeastern portion of the Livermore Valley, a topographical and structural depression oriented east-west within the Diablo Range of the California Coast Range Province. The Livermore Valley forms an irregularly shaped lowland area approximately 26 km long and an average of 11 km wide. The floor of the valley slopes from an elevation of approximately 200 m at the eastern end to approximately 90 m at the southwest corner.

The climate of the Livermore Valley is characterized by mild, rainy winters and warm, dry summers. The mean annual temperature is about 15°C (in 1995, the mean annual temperature was 15.2°C). Temperatures typically range from –5°C during some pre-dawn hours during the winter, to 35°C on a few summer afternoons. The 1995 annual wind data for the Livermore site are shown in Table 1 and displayed as a wind rose in Figure 2. Although winds are variable, the prevailing wind direction is from the southwest, especially during the summer. However, the wind often blows from the northeast, usually during the winter. Most precipitation occurs as rain between October and April with very little rainfall during the summer months. In 1995, the Livermore site received 541 mm of precipitation.

Site 300: Site 300, LLNL's Experimental Test Site, is located 24 km east of the Livermore site in the Altamont Hills of the Diablo Range and occupies an area of 30.3 km^2. It is close to two other explosives-testing facilities; one operated by Physics International, the other by SRI International. A State of California vehicular-recreation area is located nearby, and wind-turbine generators line the surrounding hills. The remainder of the surrounding area is in agricultural use, primarily pasture land for cattle and sheep. The nearest residential area is the City of Tracy (population 40,000), located 10 km to the northeast.

The topography of Site 300 is much more irregular than that of the Livermore site; it consists of a series of steep hills and ridges, which are oriented along a generally northwest/southeast trend, separated by intervening ravines. The elevation ranges from approximately 540 m in the northwestern portion of the site to 150 m at the southeast corner.

Table 1. Wind rose for LLNL's Livermore site during 1995 at the 10-m level. Values are frequency of occurrence (in percent). Columns and rows may not exactly sum to the listed totals due to rounding error.

	Wind Speed Range (m/s)					
Direction	0.0-0.4	0.5-2.9	3.0-4.9	5.0-6.9	≥7.0	Total
NNE	1.03	2.71	1.83	0.56	0.12	6.4
NE	1.03	4.16	1.42	0.02	0.00	6.6
ENE	1.03	2.73	0.04	0.00	0.00	3.8
E	1.03	1.64	0.00	0.00	0.00	2.7
ESE	1.03	1.56	0.00	0.00	0.00	2.6
SE	1.03	1.34	0.11	0.00	0.00	2.5
SSE	1.03	1.43	0.34	0.08	0.00	2.9
S	1.03	4.23	0.70	0.41	0.18	6.6
SSW	1.03	6.10	2.01	0.80	0.28	10.2
SW	1.03	7.72	7.65	2.68	0.14	19.2
WSW	1.03	8.06	4.79	0.93	0.12	14.9
W	1.03	4.46	5.57	0.96	0.00	12.0
WNW	1.03	1.88	0.52	0.14	0.00	3.6
NW	1.03	1.03	0.14	0.00	0.00	2.2
NNW	1.03	0.91	0.06	0.04	0.00	2.1
N	1.03	0.71	0.13	0.06	0.04	2.0
Total	**16.4**	**50.7**	**25.3**	**6.7**	**0.9**	**100.0**

Table 2. Wind rose for LLNL's Site 300 at the 10-m level for 1995. Values are frequency of occurrence (in percent). Columns and rows may not exactly sum to the listed totals due to rounding error.

	Wind Speed Range (m/s)					
Direction	0.0-0.4	0.5-4.9	5.0-6.9	7.0-10.9	≥11.0	Total
NNE	0.04	1.82	0.05	0.00	0.00	1.9
NE	0.04	2.16	0.10	0.00	0.00	2.3
ENE	0.04	2.00	0.06	0.02	0.00	2.1
E	0.04	1.85	0.13	0.13	0.00	2.2
ESE	0.04	2.21	0.50	0.50	0.12	3.4
SE	0.04	3.09	0.37	0.34	0.16	4.0
SSE	0.04	2.43	0.15	0.17	0.12	2.9
S	0.04	3.43	0.64	0.17	0.05	4.3
SSW	0.04	2.05	0.24	0.12	0.02	2.5
SW	0.04	1.86	0.84	1.59	0.29	4.6
WSW	0.04	3.37	4.71	17.46	5.35	30.9
W	0.04	4.14	4.13	2.18	0.10	10.6
WNW	0.04	4.08	1.03	0.49	0.00	5.6
NW	0.04	5.84	1.62	1.75	0.19	9.4
NNW	0.04	4.25	3.02	1.98	1.06	10.4
N	0.04	1.35	1.14	0.24	0.07	2.8
Total	**0.7**	**45.9**	**18.7**	**27.1**	**7.5**	**100.0**

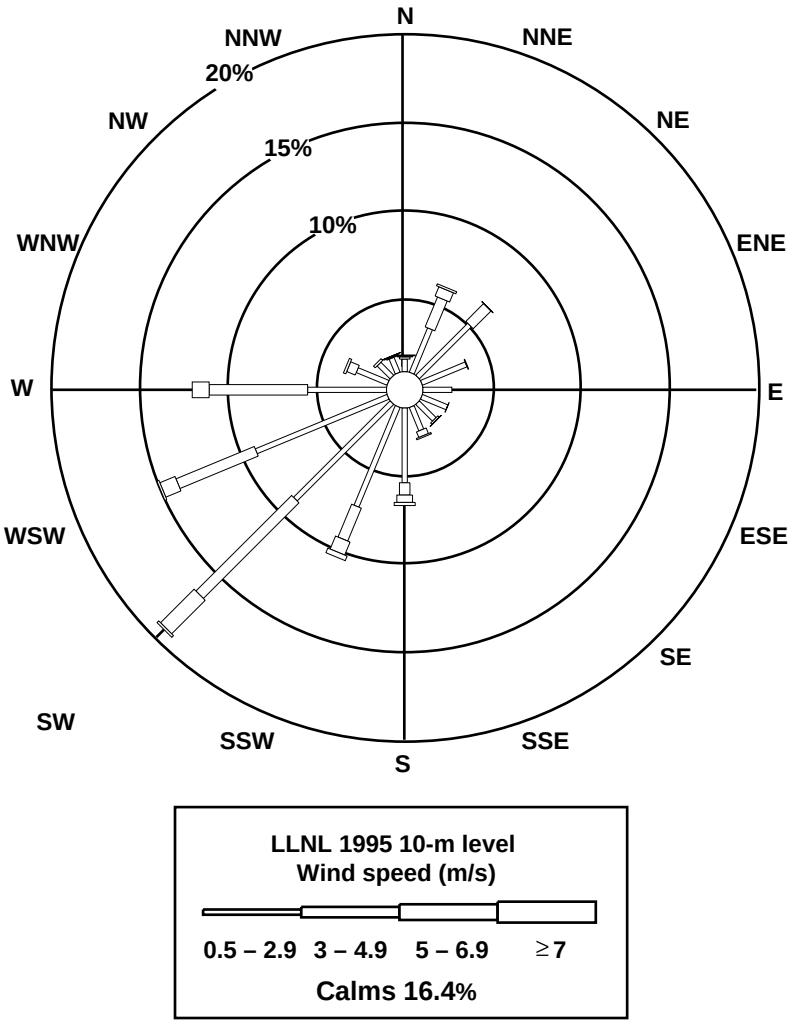

Figure 2. Wind rose showing the average annual wind speed, frequency of occurrence, and direction at the Livermore site, 1995.

The climate at Site 300 is similar to that of the Livermore site, with mild winters and dry summers. The complex topography of the site significantly influences local wind and temperature patterns, making the temperature range somewhat more extreme than at the Livermore site. The average annual temperature was 16.6°C in 1995. The 1995 annual wind data for Site 300 are shown in Table 2 and displayed as a wind rose in Figure 3. Prevailing winds are from the west-southwest. As is the case at the Livermore site, precipitation is highly seasonal, with most precipitation occurring between October and April. The average annual rainfall over the past 20 years was 257 mm; Site 300 received 412 mm of precipitation during 1995.

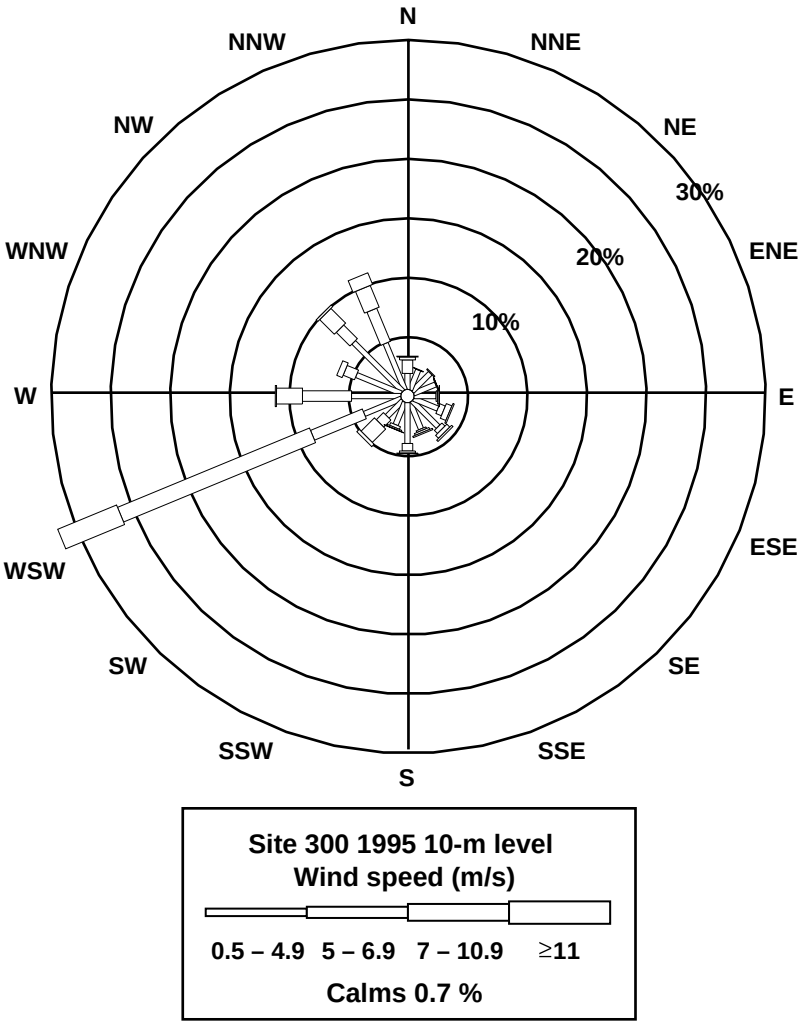

Figure 3. Wind rose showing the average annual wind speed, frequency of occurrence, and direction at Site 300, 1995.

Source Description

Many different radioisotopes are used at LLNL for research purposes, including transuranics, biomedical tracers, tritium, mixed fission products, and others (Table 3). Radioisotope-handling procedures and work enclosures are determined for each project, depending on the isotopes, the quantities being used, and the types of operations being performed. Radioisotope handling and working environments include glove boxes, exhaust hoods, and laboratory bench tops. Exhaust paths to the atmosphere range from triple-HEPA (High-Efficiency-Particulate-Air)-filtered stacks, to roof vents and stacks lacking abatement devices, to direct dispersal of depleted uranium during explosives testing at Site 300, to a variety of diffuse-area sources.

Table 3. Radionuclides used at LLNL during 1995.

^{3}H	^{57}Co	^{129}I	^{218}Po	^{236}Pu	^{242}Pu
^{13}N	^{59}Ni	^{133}Ba	^{222}Rn	^{236}U	^{243}Am
^{14}C	^{60}Co	^{137}Cs	^{226}Ra	^{237}Np	^{243}Cm
^{15}O	^{63}Ni	^{144}Ce	^{228}Th	^{238}Pu	^{244}Cm
^{22}Na	^{90}Sr	^{152}Eu	^{230}Th	^{238}U	^{244}Pu
^{32}P	^{90}Y	^{154}Eu	^{231}Pa	^{239}Np	^{248}Cm
^{33}P	^{99}Tc	^{155}Eu	^{232}U	^{239}Pu	^{252}Cf
^{35}S	^{106}Ru	^{207}Bi	^{233}U	^{240}Pu	
^{40}K	^{125}I	^{214}Bi	^{234}U	^{241}Am	
^{54}Mn	^{125}Sb	^{214}Pb	^{235}U	^{242}Cm	

SECTION II. Air-Emission Data

Sources

At LLNL, areas where radioactive materials are used or stored, or where activation products occur, are called Radioactive Materials Management Areas (RMMAs). Detailed information is given in Attachment 1 for point-source emissions from the Livermore-site RMMAs in which radiological operations took place during 1995. Building 514 and four other Livermore-site sources external to buildings (including the RMMA at the Building 612 Hazardous Waste Management Yard) are treated as diffuse-area sources.

Similarly, detailed information is given in Attachment 1 for experiments at three Site 300 explosives-testing facilities (Buildings 801, 850, and 851 and their associated firing tables). Six Site 300 sources, including the three firing tables where surface and subsurface contamination exists, are treated as diffuse-area sources.

1995 Inventory Update and Effective Dose Equivalent (EDE) Calculations

For this year's report, covering activities in 1995, we updated the radionuclide inventories in our key facilities, defined as those that accounted for 90% of the 1994 Livermore site radiological dose to members of the public. We also inventoried all RMMAs that began operations in 1995. Radionuclide inventory forms, with detailed guidance for completing them, were sent to the these key unmonitored facilities and new unmonitored facilities having the potential for radionuclide emissions to the air. The forms were completed

by experimenters, and certified by facility managers. Radionuclide inventories for all Site 300 explosives experiments and assessments of source terms for known diffuse sources at both sites were also updated.

Dose-assessment modeling runs were conducted for all diffuse sources and for all point sources using actual radionuclide releases to air, or potential releases based on inventory data completed in 1995. The model used was CAP88-PC (see Section III); we incorporated 1995 on-site meteorological data (wind, precipitation, and temperature) along with the 1995 radionuclide inventory or monitoring data. Annual dose is reported as whole-body EDE expressed in units of mrem (μSv). When reasonable to do so, modeling runs were combined by building, rather than a separate model run for each stack or room. This is permitted by the Memorandum of Understanding between the U.S. EPA and the DOE concerning radionuclide NESHAPs.

A generalized description of each facility and its operations is provided in Attachment 1. The following information is shown for each listed emission point or stack:

- Building and room number(s)
- Specific stack identification code(s)
- Generalized operations in the room(s) or area(s)
- Radionuclides utilized during 1995
- Annual radionuclide inventory with potential for release (by isotope, in curies)
- Physical-state factors (by isotope)
- Stack parameters
- Emission-control devices and emission-control-device abatement factors
- Estimated or measured annual emissions (by isotope)
- Distance and direction to the site-wide maximally exposed individual (SW-MEI)
- Calculated EDE to the SW-MEI
- Distance and direction to the maximally exposed individual for that specific source (MEI)
- Calculated EDE to the MEI (source term not adjusted for emission controls)
- Source category
- Below Appendix E Quantity (Y or N)

A more complete description of these terms is provided in introductory material to the attachment.

The radionuclides shown in the attachment are those from specific emission points where air emissions were possible. If radionuclides were present, but encapsulated or sealed for the entire year, radionuclides, annual inventories, and emissions are not listed.

Actual measurements of air radioactivity and effluent flow are the basis for reported emissions from continuously monitored sources. LLNL facilities that have continuously monitored discharge points are Buildings 166, 175, 231-vault, 251, 331, 332, 419, 490, and 491. For most of the discharge points, sample results are below the limit-of-sensitivity (LOS) of the analysis; sometimes as few as 1 or 2 samples (out of 25 to 50 per year) have concentrations greater than the LOS. Generally, these few samples having results above the LOS are only marginally above the LOS. Use of zero values for this type of data can be justified based on facility knowledge, the use of multiple-stage HEPA filters in all significant release pathways, and alpha-spectroscopy-based isotopic analyses of selected air-sampling filters. These isotopic analyses demonstrate that detected activity on air-sampling filters comes from naturally occurring radionuclides, such as radon daughters, e.g., polonium. In addition, because of exhaust configurations at some facilities, the monitoring systems sometimes sample air from the ambient atmosphere along with the HEPA-filtered air from facility operations giving rise to background atmospheric radioactivity being collected. Because of these considerations, the emissions from such facility operations are reported as zero. Furthermore, even if the LOS values are used in calculations of the emission estimates for these facilities, an extremely conservative approach, the total dose attributable to LLNL activities is not significantly affected.

Three emission points at two facilities, Buildings 251 (Unhardened Area) and 419, yielded gross alpha results greater than the LOS on a majority of the samples collected throughout the year. We use gross alpha as the primary indicator of potential emissions for operations, such as those at Buildings 251 and 419, that involve the use of transuranic materials. The gross alpha monitoring concentrations for these buildings ranged from 1.0×10^{-15} Ci/m^3 (3.7×10^{-5} Bq/m^3) to 1.3×10^{-14} Ci/m^3 (4.8×10^{-4} Bq/m^3). Because so many samples indicated values above the LOS, we have taken a conservative approach and reported gross alpha and gross beta measurements as actual emissions. The gross alpha and gross beta emissions for Building 251 were determined to be 7.5×10^{-8} Ci/y (2.8×10^3 Bq/y) and 8.1×10^{-7} Ci/y (3.0×10^4 Bq/y), and the gross alpha and gross beta emissions derived from the measured concentrations for Building 419 were 2.4×10^{-7} Ci/y (8.9×10^3 Bq/y)and 2.3×10^{-6} Ci/y (8.5×10^4 Bq/y). We have not confirmed these to be

emissions by isotopic analysis, so it is possible that these, too, are due to naturally occurring, or background, radioactivity, as discussed above. However, the resulting dose at the SW-MEI for Building 251 was 1.5×10^{-5} mrem/y (1.5×10^{-4} μSv/y) and for Building 419 was 1.6×10^{-4} mrem/y (1.6×10^{-3} μSv/y), well below the NESHAPs limit of 10 mrem/y (1.0×10^{2} μSv/y). In addition, no measured activity concentrations were above facility notification levels, which are designed to trigger investigations of potential releases. These levels are 1×10^{-13} Ci/m^3 (3.7×10^{-3} Bq/m^3) for gross alpha or 1×10^{-11} Ci/m^3 (3.7×10^{-1} Bq/m^3) for gross beta.

SECTION III. Dose Assessment

Description of Dose Model

Estimates of individual and collective radiological doses to the public from all point sources and most diffuse sources at LLNL were obtained using the EPA-developed computer code CAP88-PC. The four principal pathways—internal exposures from inhalation of air and ingestion of foodstuffs and drinking water, and external exposures through irradiation from contaminated ground and immersion in contaminated air—are evaluated by CAP88-PC. The doses are expressed as whole-body effective dose equivalents (EDEs), in units of mrem/y (1 mrem = 10 μSv). Separate doses for the Livermore site and Site 300 from point-source emissions (i.e., stack emissions) and diffuse-source emissions at the two sites are reported.

Three potential doses are emphasized: (1) The dose to the site-wide maximally exposed individual (SW-MEI), which combines the effects of all emission points, for evaluation under the 10 mrem/y (100 μSv/y) standard; (2) the maximum dose to any member of the public (conservatively assumed to be at the LLNL fence line), in any direction, due to each unabated emission point on the site for evaluation of the need to conduct continuous monitoring; and (3) the collective dose to the populations residing within 80 km of the two LLNL sites, adding the products of individual doses received times the number of people receiving them.

Summary of Model Input Parameters

General Model Inputs: Attachment 1 details the key identifiers and input parameters for the CAP88-PC model runs. These include building number; stack ID; isotope(s); emission rate in curies per year (1 Ci = 3.7×10^{10} Bq); and stack parameters, including height, diameter, and emission velocity.

Meteorological Data: All model runs used actual 1995 Livermore-site and Site 300 meteorological data, collected from the meteorological towers for each site. At these towers, wind speed and direction are sampled every few seconds, temperature every minute; and all are averaged into quarter-hour increments, time-tagged, and computer-recorded. The data are converted into a CAP88-PC input wind file using EPA guidelines.

Surrogate Radionuclides: Because the EPA-mandated model CAP88-PC does not contain all the radionuclides in use at LLNL, it was necessary in a few cases to use surrogate radionuclides to estimate EDEs. Attachment 2 shows the surrogate radionuclide lists for CAP88-PC. In selecting the surrogates, the most-restrictive lung class (whether clearance from the lungs takes place in days, weeks, or years) was used. When possible, a surrogate radionuclide with similar chemistry and similar values for "annual limits of intake via inhalation and derived air concentration," as specified in the EPA's Federal Guidance Report No. 11 was used. CAP88-PC contains a library of 265 radionuclides. In some cases, experimenters did not have isotopic analyses of mixtures of radionuclides and could only identify their radionuclide inventory as "gross alpha" or "gross beta." In these cases, ^{239}Pu was used as the surrogate for gross alpha and ^{90}Sr was used as the surrogate for gross beta in modeling efforts to provide conservative dose estimates.

Population Inputs: Population distributions centered on the two LLNL sites were compiled from 1990 census data. The population data files (distribution of population with distance and direction) used in the 1995 modeling effort are described in Section VI under "Collective Effective Dose Equivalent."

Land-Use and Agricultural Inputs: Options for model inputs regarding agricultural characteristics and land use are established by the EPA, and the particular designation selected can strongly influence the ingestion dose received by the population being evaluated. Following investigation into the use of the various options, the "user entered" option was selected for the CAP88-PC modeling effort for 1995. The values entered corresponded to the "local agriculture" option (i.e., everything is home produced), with one exception—all milk consumed was assumed to be imported. The assumption that all milk comes from local cows is not supported by the agricultural activities conducted in the area. The greatest effect of this change is found in the dose from the ingestion pathway attributable to tritium. A detailed discussion of how the dose from tritium is calculated by CAP88-PC is presented in Attachment 3.

Emission Source Terms: The source term(s) from each emission point in the calculations was determined by one of two methods: For continuously monitored sources, the sampling data (curies released per unit time) for each radionuclide were used directly. For unmonitored facilities, the radionuclide inventories, together with the EPA-specified fractions for potential release to air of materials in different physical states (solid, liquid, powder, or gas), in accordance with 40 CFR Part 61, Appendix D were used. The state-dependent release fraction was used to adjust (by multiplication) the total annual inventory to yield the potential annual release to air. If the material was an unconfined gas, then the fraction 1.0 was used; for liquids and powders, 1.0×10^{-3} was used; and for solids, 1.0×10^{-6} was used. In addition, emission-control abatement factors (40 CFR 61, Appendix D), when applicable, were applied. Each HEPA filter stage was given a 0.01 factor, electrostatic precipitators, as well as venturi scrubbers, were each given a 0.05 factor, and each activated-charcoal filter was given a 0.1 factor. The use of actual monitoring data is much more direct, and presumably more accurate, than using assumptions based on inventory, release fractions, and emission-control factors.

Site-Wide Maximally Exposed Individual: For LLNL to comply with the NESHAPs regulations, the LLNL site-wide maximally exposed individual cannot receive an EDE greater than 10 mrem/y (100 μSv/y). The site-wide maximally exposed individual (SW-MEI) is defined as the *hypothetical* member of the public at a single residence, school, business, or office who receives the greatest LLNL-induced EDE from the combination of all radionuclide source emissions.

To determine the location of the 1995 SW-MEI, CAP88-PC results from multiple sources were combined. Sources were selected to include those expected to give significant contributions to the EDE. These included Building 331 point and area sources, Building 514 Tank Farm, and Building 612 area source. Because EDE results from CAP88-PC are relative to the location of the specified source, direct summing of results from multiple sources can only be accomplished using an interpolation method. To do this, the location of each selected source relative to a common location (the Livermore-site center) and a set of receptor locations (where the combined EDEs from the selected sources were to be evaluated), also relative to the site center, were specified in the modeling efforts that supported determination of the SW-MEI. The receptor locations included 48 equally spaced directions from the site center and 4 additional receptor locations along the eastern and southern Livermore-site boundaries. The interpolation method was used to calculate the EDEs for the desired set of receptor locations for each source.

These resulting interpolated EDEs for each source, now for the same set of locations, were then summed, and the SW-MEI determined.

At the Livermore site, the SW-MEI for 1995 was located at the UNCLE Credit Union, about 10 m outside the controlled eastern perimeter of the site, as shown in Figure 4.

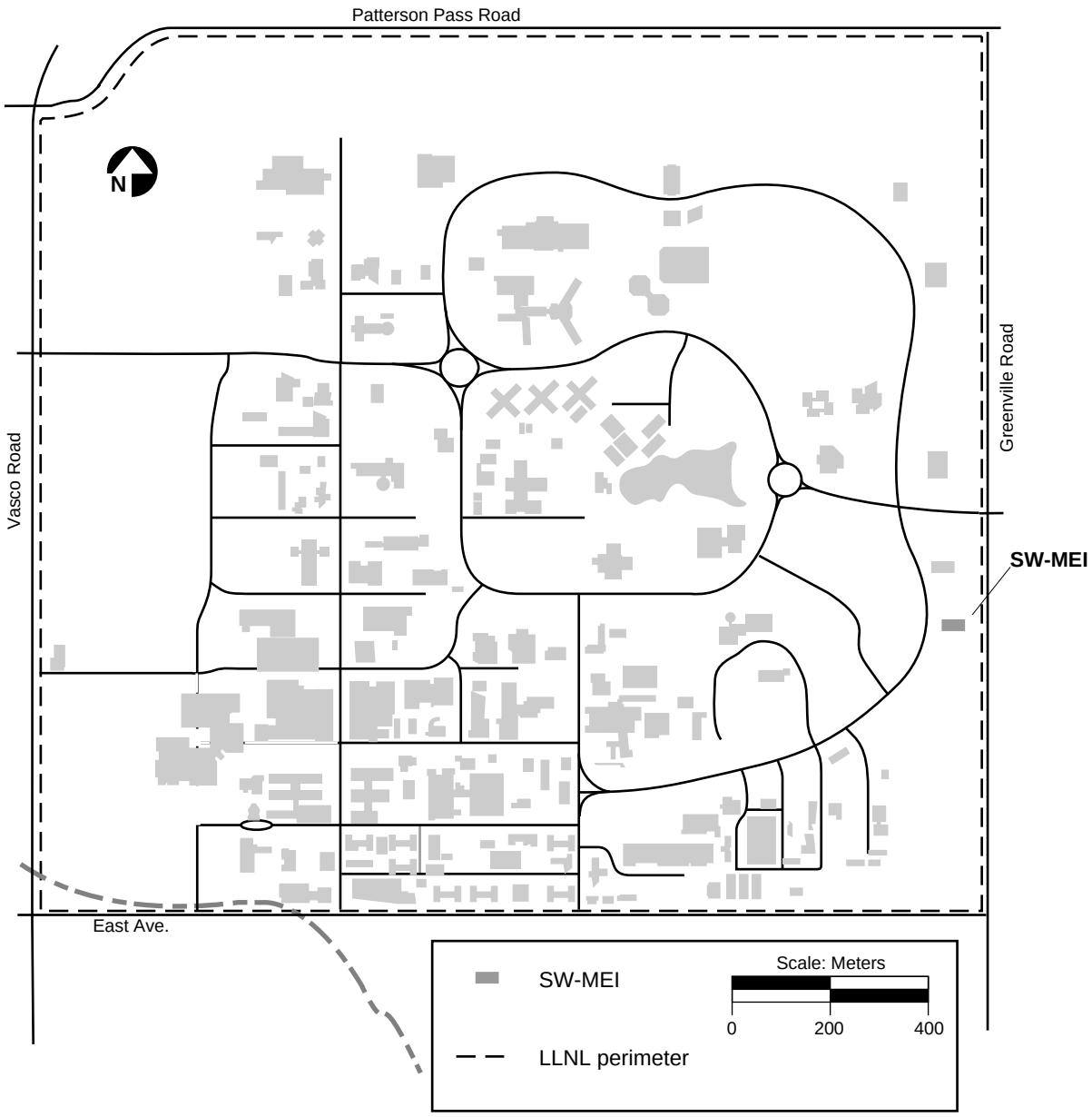

Figure 4. Location of Site-Wide Maximally Exposed Individual (SW-MEI) at the Livermore site, 1995.

At Site 300, the 1995 SW-MEI was located in an experimental area termed "Bunker 2" operated by Physics International. Bunker 2 lies about 300 m outside the east-central boundary of Site 300, as shown in Figure 5. This bunker is 2.4 km east-southeast of the principal firing table at Building 801.

In Attachment 1, the distance and direction to the respective SW-MEI are shown for each facility at each site. Doses to the site-specific SW-MEIs were evaluated for each source and then totaled for site-specific evaluations against the 10 mrem/y dose standard (see "Compliance Assessment" in Section III).

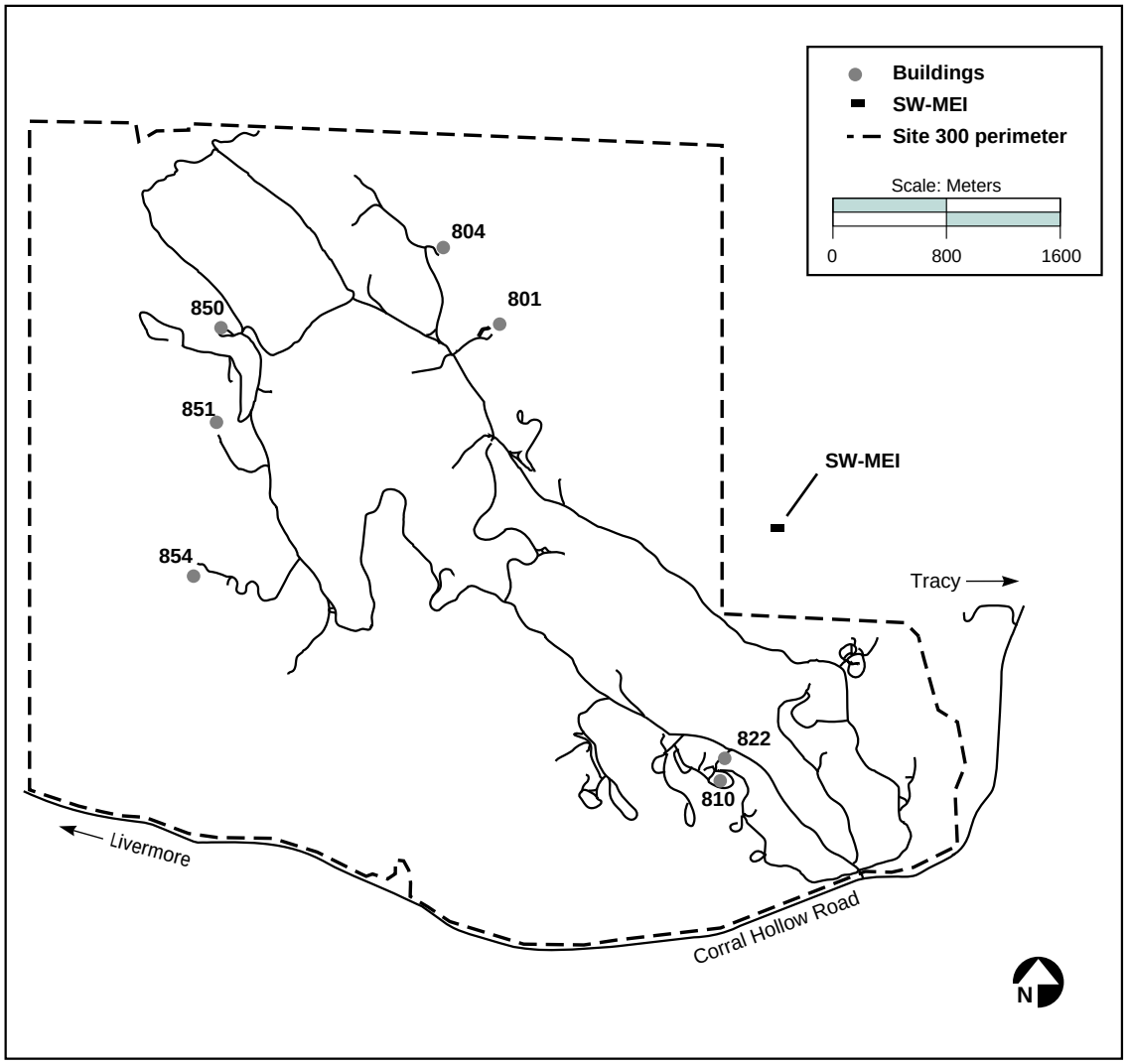

Figure 5. Location of Site-Wide Maximally Exposed Individual (SW-MEI) at Site 300, 1995.

Maximally Exposed Public Individual: To assess compliance with the requirement for continuous monitoring (potential dose greater than 0.1 mrem/y {1.0 μSv/y}), emissions must be individually evaluated from each point source; the location of the maximally exposed public individual (MEI) is generally different for each emission point. The maximum dose at a location of unrestricted public access typically occurs at a point on the site perimeter. Therefore, it is often referred to as the maximum "fence line" dose, although the off-site maximum dose could occur some distance beyond the perimeter. (This could happen, e.g., when the perimeter is close to a stack; however, for all emission points at the Livermore site and Site 300, calculations show that ground-level concentrations of radionuclides decline monotonically beyond LLNL boundaries.) As stipulated by the regulations, modeling for assessment of continuous monitoring requirements assumed unabated emissions (i.e., no credit was taken for emission abatement devices, such as filters), but physical-state factors were applied. Attachment 1 provides, for each point source, the dose to the MEI and the distance and direction to the LLNL fence line where the MEI is located.

Special Modeling Challenges: Among the sources at LLNL, explosives tests using depleted uranium at Site 300 and diffuse sources at the two sites required special attention.

Site 300 Explosives Experiments: During Site 300 explosives experiments, the device containing depleted uranium is placed on an open-air firing table and detonated. Only limited data are available to characterize the initial state of the cloud of explosive decomposition products created by the detonation because properties of the cloud are not routinely measured in the experiments. Empirical scaling laws can be used, however, to define the cloud using the radionuclide and explosives inventories. Isotopic ratios for depleted uranium are used; the three uranium isotopes with atomic weights 238, 235, and 234 occur in the weight percentages 99.8, 0.2, and 5×10^{-4}, respectively. Their masses are multiplied by their respective specific activities to determine the total number of curies for each isotope in the cloud. It is assumed that all the uranium is dispersed into the cloud, and the median particle size is assumed to be the CAP88-PC default value of 1 μm. The assumption that all uranium is aerosolized and dispersed as a cloud results in a highly conservative off-site dose estimation—we believe a more realistic release-to-air fraction for the uranium is no greater than 0.2, but we lack sufficient data to use a value other than 1.0. CAP88-PC simulates each shot as a low-level, steady-state, stack-type emission occurring over one year. An alternative modeling methodology for treating these short-duration

explosive events was submitted for approval in 1992, but LLNL was directed by EPA to use the CAP88-PC code for these calculations.

Diffuse Sources: Diffuse emissions are generally area sources external to buildings, as discussed in Section IV, below. The dose assessments for diffuse sources can be derived from modeling based on radionuclide-inventory data, or can be determined from environmental-surveillance monitoring data.

Modeling Documentation: Copies of individual model runs, including input parameters and resultant calculated doses, are on file with the Terrestrial & Atmospheric Monitoring & Modeling Group (TAMM) of the Environmental Protection Department at LLNL.

Compliance Assessment

The 1995 calculated EDE to the SW-MEI from Livermore-site point sources was 0.019 mrem (0.19 μSv). Emissions from the two 30-meter stacks at the LLNL Tritium Facility (Building 331) accounted for 0.017 mrem (0.17 μSv), or 89%, of the Livermore-site point-source total. No other point source at the Livermore site contributed as much as 4% to this total.

The calculated EDE to the SW-MEI at Site 300 was calculated to be 0.020 mrem (0.20 μSv) from point-source emissions. All of this EDE resulted from Building 801 and Building 851 firing-table emissions in the course of explosives experiments—60% from the former and 40% from the latter.

All the dose evaluations from point-source emissions, and those from most diffuse sources discussed below, were made using the EPA-mandated CAP88-PC dispersion model. They result in levels of public exposure well below the EPA standard, which limits the whole-body EDE to members of the public from DOE activities to 10 mrem/y (100 μSv/y).

SECTION IV. Additional Information

Construction and Modifications

During 1995, no construction projects or modifications were completed for which approval to construct or modify was required or waived under 40 CFR 61.96. Only maintenance, repair, and replacement activities, as well as those considered normal or routine, were conducted. Proposed facilities and

significantly modified operations are assessed for NESHAPs requirements during the National Environmental Policy Act (NEPA) process. Under NEPA, all proposed projects or actions that might involve NESHAPs issues or concerns—not just pertaining to radionuclides but to air toxics as well—are reviewed and evaluated. If the proposal includes operations that require a NESHAPs assessment, necessary modeling is conducted. If insufficient information is available for modeling at the time the NEPA documents are prepared, LLNL includes in the NEPA documents a statement that NESHAPs review, modeling, and monitoring requirements will be met. It is the responsibility of the individual project proponent to supply the specific information required for any NESHAPs modeling, analysis, and review that must be completed before operations described in the document are initiated.

Unplanned Releases

There were no unplanned atmospheric radionuclide releases from the Livermore site or from Site 300 in 1995.

Diffuse Source Dose Assessments

Diffuse, or non-point, sources are difficult to quantify. There are no EPA-mandated methods for estimation or measurement, although LLNL did review a second draft of EPA guidance on this topic during 1994. At this time, however, dose calculations associated with this type of source remain left to the discretion of the DOE facility. Livermore-site and Site 300 diffuse sources are described separately.

Livermore-Site Diffuse Sources

The dose calculations from 1995 diffuse sources at the Livermore site required four different modeling approaches. Building 292 and Building 419 required a calculation of source term and the use of CAP88-PC; Building 331 and the Building 612 Yard needed facility personnel knowledge and environmental-surveillance data to estimate emissions; Building 514 required radiological-inventory data and CAP88-PC modeling techniques; and in the Southeast Quadrant, data from ambient-air monitoring were used to calculate the dose.

Building 292: Elevated tritium concentrations in soil moisture near Building 292 resulted from a historic leak in an underground retention tank. This contamination has resulted in diffuse tritium emissions from evaporation of soil moisture and transpiration from vegetation. Measurements and calculations during 1994 showed transpiration from a single pine tree

accounted for the largest amount of tritium released to the atmosphere in this area. The total annual emissions from this pine tree were calculated based on estimated projected area (79 m^2) and collective transpiration rate (190 liter/day), together with average measured concentrations of tritium in transpired water (annual mean of 11,750 pCi/liter or 435 Bq/liter), producing a 1994 emission of 8.2×10^{-4} Ci (3.0×10^7 Bq). The annual tritium release to the atmosphere stemming from evaporation of soil moisture was represented by generous upper-bound estimates. A high value for the measured tritium flux from the ground near the tank was 0.26 μCi/m^2/y (9.6×10^3 Bq/m^2/y). Assuming 400 m^2 effective soil area, based on isoactivity contours, this gave an annual soil-evaporation release of 1.7×10^{-5} Ci (6.3×10^5 Bq). The total tritium emissions from the Building 292 diffuse source were, therefore, determined to be 8.4×10^{-4} Ci (3.1×10^7 Bq) during 1994. Budgetary constraints precluded taking precise measurements of tritium transpiration from the pine tree and tritium flux from soil in 1995; however, local ambient air tritium measurements have been made since 1991. For 1995, the median tritium in air from a sampler located near Building 292 was 3.7×10^{-12} μCi/mL (1.4×10^{-7} Bq/mL). The ratio of measured ambient air tritium for 1995 to 1994 of 0.57 (3.7×10^{-12} μCi/mL divided by 6.5×10^{-12} μCi/mL) when applied to the 1994 estimated source term yields an emission estimate of 4.8×10^{-4} Ci (1.8×10^7 Bq) for 1995. The resultant 1995 EDE to the SW-MEI based on CAP88-PC modeling was 1.3×10^{-7} mrem (1.3×10^{-6} μSv).

Building 331: As the Tritium Facility (Building 331) undergoes both decommissioning/decontamination and redirection of its research and development efforts, tritium-contaminated equipment slated for disposal is removed from the building, packaged in a waste-accumulation area, and sent to Hazardous Waste Management Division (HWM) facilities. During 1995, outgassing from such waste processing released approximately 4 Ci (1.5×10^{11} Bq) of tritium to the atmosphere outside Building 331. The estimated releases were derived from measurements of surface contamination on the material, process and facility knowledge, and environmental-surveillance measurements. The estimated 4 Ci (1.5×10^{11} Bq) release was modeled in CAP88-PC as a 1 m^2 area source, leading to a calculated 1995 dose to the SW-MEI of 5.9×10^{-3} mrem (5.9×10^{-2} μSv).

Building 419 Pipe Removal: During tank upgrade activities in 1995, piping associated with tanks 419-R1U4 and 419-R1U5 near Building 419 was found to have leaked. Analysis of soil in the area showed some contamination with tritium. About 0.1 m^3 of soil from soils about 0.3 m deep had an average contamination of 1.36×10^1 pCi/mL (0.5 Bq/mL). Annual tritium flux was calculated from tritium activity data and was estimated to be 2.17×10^{-2} Ci

(8.0×10^8 Bq) for 1995. This source term produced a calculated 1995 dose to the SW-MEI of 4.6×10^{-5} mrem (4.6×10^{-4} μSv).

Building 514: Another potential source of diffuse emissions of a variety of radionuclides was HWM waste-storage and treatment operations. Building 514 houses the HWM "tank farm," consisting of six 7,170-liter tanks with ancillary equipment such as pumps, mixers, probes, and a bulking station. The tanks are used to store and treat liquid and solid radioactive and/or mixed wastes. Treatment is performed on a batch basis. Chemicals and waste are added to the tanks to achieve the desired treatment objectives. A 1995 radionuclide inventory was conducted for the facility to determine the diffuse source term (Attachment 1). CAP88-PC modeling gave a 1995 EDE to the SW-MEI of 7.2×10^{-4} mrem (7.2×10^{-3} μSv).

Building 612 Yard: The Building 612 Yard is a potential source of diffuse emissions of tritium. This area is dedicated to hazardous-waste-, radioactive-waste-, and mixed-waste-management activities. The yard consists of several areas where waste containers are stacked outdoors. Many of these containers are not air tight and outgas tritium. A surveillance air monitor has been placed in the Building 612 Yard to provide continuous measurements of tritium near this source. The median annual concentration of tritium in air for 1995 in this area was 0.025 pCi/L (9.3×10^{-4} Bq/L). These data were used to calculate the total tritium emissions from the area, using a conservative approach that assumed the source to be concentrated 120 m south-southwest of the air sampler. With this assumption, CAP88-PC requires a diffuse source emission of 2.1 Ci/y (7.8×10^{10} Bq/y) to produce the concentrations measured at the air sampler. This source term produced a calculated 1995 dose to the SW-MEI from the Building 612 Yard of 1.4×10^{-2} mrem (1.4×10^{-1} μSv).

Southeast Quadrant: The Southeast Quadrant of the Livermore site has elevated levels of ^{239}Pu in the surface soil (from historic waste-management operations) and air (presumably from resuspension). A high-volume air-particulate sampler is located adjacent to the UNCLE Credit Union (the location of the SW-MEI) to monitor the ^{239}Pu levels in this area. Monitoring data from this air sampler were used as a direct measurement of potential dose via the air pathway. The mean annual concentration of ^{239}Pu in air of 2.9×10^{-19} μCi/mL (1.1×10^{-14} Bq/mL), the dose-conversion factor of 3.08×10^5 mrem/μCi (8.33×10^{-5} Sv/Bq) from Federal Guidance Report No. 11, EPA-520/1-88-020, U.S. Environmental Protection Agency (1988) for ^{239}Pu, and the standard-man breathing rates of 1×10^{-10} mL/y were used to calculate the estimated EDE of 9.4×10^{-4} mrem (9.4×10^{-3} μSv) for 1995.

Site 300 Diffuse Sources

Diffuse sources at Site 300 involve tritium and uranium. During remediation efforts at Site 300, LLNL completed a contaminant screening to identify potential routes of migration from soil to air and other environmental media of these radionuclides and other contaminants. Information provided in the Final Site Wide Remedial Investigation Report (Webster-Scholten, Ed., 1994, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-AR-108131) was used in the diffuse-source evaluations. In the course of the remedial investigation, the rate of intermedia migration and the exposure-point concentrations of contaminants were evaluated. Tritium and ^{238}U were identified as contaminants of potential concern at six locations.

Tritium contamination is well characterized at Site 300. Five diffuse tritium sources are discussed individually. Uranium, on the other hand, is not as well characterized. Diffuse uranium sources were treated collectively in a resuspension calculation, presented following the individual tritium discussions below.

Tritium gas and solid tritium (Li^3H) were components of explosives assemblies tested on the firing tables during past experiments. Most of the gaseous tritium escaped to the atmosphere during the tests, but some of the solid Li^3H remained as residue in the firing table gravel. Rainwater and dust-control rinse water percolated through the gravel, causing the tritium to migrate into the subsurface soil and, in some cases, eventually to the ground water. Tritium-contaminated gravel was removed from the firing tables in 1988 and disposed in the Pit 7 landfill. Tritium in landfills, firing-table soils, and ground water are source terms for diffuse emissions of tritium to the atmosphere at Site 300.

Pit 7 Complex: The Pit 7 Complex is an area where four landfills were established. All the pits contain gravel and debris generated from explosives tests conducted at the Building 850 and 851 firing tables. Tritium is a known residue in this waste, and tritium contamination in both subsurface soils and ground water in the area has been characterized. Tritium in subsurface moisture can evaporate to the atmosphere. The affected area is estimated at 18,000 m^2. Tritium flux was calculated from tritium activity data obtained from subsurface soil samples collected at depths from 0.15 to 3 m, and was estimated to be 9.2×10^{-1} Ci (3.4×10^{10} Bq) for 1995. A correction (decrease) in source term from the time the samples were taken accounts for both radioactive decay and loss of the original tritium activities in the soil due to evapotranspiration. In addition, well purge water (water collected from wells

and left to evaporate to the atmosphere before ground water sampling) in this area often contains elevated levels of tritium. During 1995, ground water monitoring operations involved purging three wells with tritium levels above 20,000 pCi/L (740 Bq/L). The evaporation of this water to the atmosphere represents another component of the Pit 7 diffuse emission source term; it was estimated to contribute 1.3×10^8 pCi (4.8×10^6 Bq) during 1995. This emission estimate is based on the total volume of water purged during monitoring activities and the detection levels reported in the 1995 LLNL Site 300 Compliance Monitoring Program Report (UCAR-10191-95-5). The 1995 calculated EDE to the SW-MEI from the combined tritium emissions at the Pit 7 Complex was 3.5×10^{-5} mrem (3.5×10^{-4} μSv).

Well 8 Spring: Tritium released to the soils, and eventually to the ground water, near the Building 850 firing table has been transported to areas where ground water flows near the surface and can evaporate to the atmosphere. Such is the case at the Well 8 Spring, where ground water is very shallow. To estimate tritium flux from this spring, tritium activity data obtained from water samples collected at the spring were used. These data were corrected for radioactive decay, but not for removal by evapotranspiration because the spring was assumed to have a continuous source of tritiated water for the period in question. The affected area of the spring was estimated at 9.3 m^2, and the 1995 source term was estimated to be 2.3×10^{-3} Ci (8.5×10^7 Bq). The 1995 calculated EDE to the SW-MEI from tritium emissions at the Well 8 Spring was 1.4×10^{-7} mrem (1.4×10^{-6} μSv).

Building 802: Tritium in the subsurface soils near the Building 802 firing table may evaporate to the atmosphere. The affected area was estimated to be 900 m^2. Tritium flux was calculated from tritium activity data obtained from subsurface soil samples collected at depths from 0.15 to 3 m. The tritium emission rate from subsurface soils to air was the product of the spatial-average tritium flux, the natural flux of water, the fraction of tritium in the water, and the affected surface area. The 1995 tritium emissions from this source were estimated to be 5.6×10^{-4} Ci (2.1×10^7 Bq). The 1995 calculated EDE to the SW-MEI from tritium emissions at Building 802 was 6.2×10^{-8} mrem (6.2×10^{-7} μSv).

Building 850: Approximately 2.1×10^4 Ci (7.8×10^{14} Bq) of tritium was expended in explosives tests at the Building 850 firing table in the past. Although a significant source of tritium (firing-table gravel) was removed from the area during 1988, tritium remains in subsurface soils beneath the Building 850 firing table, sand pile area, and lower corporation yard. Tritium

in the subsurface soils in the vicinity can evaporate to the atmosphere. The affected area was estimated to be 20,000 m^2. The tritium flux and tritium emission rate from subsurface soil to air were calculated as in the Building 802 case. The 1995 tritium emissions from this source were estimated to be 1.1×10^{-1} Ci (4.1×10^{9} Bq). The 1995 calculated EDE to the SW-MEI from tritium emissions at Building 850 was 6.2×10^{-6} mrem (6.2×10^{-5} μSv).

Building 851: About 1.0×10^{3} Ci (3.7×10^{13} Bq) of tritium were expended during past explosives research conducted at the Building 851 firing table. Although gravel was removed routinely from the area, subsurface soil below the firing table contains residual tritium in soil moisture that can evaporate to the atmosphere. The affected area was estimated to be 470 m^2. The tritium flux and tritium emission rate from subsurface soil to air were calculated as in the Building 802 case. The 1995 tritium emissions from this source were estimated to be 3.3×10^{-4} Ci (1.2×10^{7} Bq). The 1995 calculated EDE to the SW-MEI from tritium emissions at Building 850 was 2.1×10^{-8} mrem (2.1×10^{-7} μSv).

Resuspension of Depleted Uranium at Site 300: Like tritium, depleted uranium has been used as a component of explosives-test assemblies. It remains as a residue in surface soils, especially near the firing tables. Because surface soil is subject to resuspension by the action of wind, rain, and other environmental disturbances, the collective effects of surface soil uranium residuals on off-site doses were evaluated.

For the 1993 and 1994 NESHAPs annual reports, we included in the calculated dose to the Site Wide Maximally Exposed Individual (SW-MEI) for Site 300 a contribution from resuspended uranium at the Site. The source of the resuspended uranium is both naturally occurring uranium (NU) and "depleted" uranium (DU) contributed by Site 300 operations, in particular, explosives experiments conducted on the firing tables. We based our dose estimate on the measured environmental surveillance monitoring total concentration in air of uranium-238, without attempting to subtract out the part contributed by NU, resulting in a dose estimate well above that to be expected from operations-contributed resuspended uranium.

Eliminating the Contribution from Natural Background Radiation: Broken down by weight percentages of constituent isotopes, NU is 99.274% U-238, 0.72% U-235, and 0.0057% U-234; the corresponding weight percentages for DU are 99.8% U-238, 0.2% U-235 and 0.0005% U-234. Thus the isotopes U-238 and U-235 are present in the ratio 499-to-1 in DU, but only 138-to-1 in

NU, and this difference can be used to distinguish between operations-contributed and natural-background-contributed components of the total measured concentration of uranium in air.

Let us denote the fraction (by weight) of uranium contributed by operations as μ and assume the fraction from natural background is then 1 – μ (i.e., we assume these are the only possible sources of uranium at Site 300). Then we can arrive at an expression for μ by writing equations for each uranium isotope as the sum of components from NU and DU. For notation, let M(DU-235) represent the mass, in grams, of the isotope U-235 in DU, M(NU-235) the mass of U-235 in NU, M(CU-235) the mass of U-235 in the composite (measured) uranium, and similarly for U-238 in the three "kinds" of uranium—depleted, natural, and composite. Then

$$M(CU–235) = \mu \bullet M(DU–235) + (1-\mu) \bullet M(NU–235),$$

and

$$M(CU–238) = \mu \bullet M(DU–238) + (1–\mu) \bullet M(NU–238).$$

The ratio of these equations is

$$\frac{M(CU-235)}{M(CU-238)} = \frac{\mu \bullet M(DU-235) + (1-\mu) \bullet M(NU-235)}{\mu \bullet M(DU-238) + (1-\mu) \bullet M(NU-238)} .$$

We have available to us the measured CU for ^{235}U and ^{238}U. The apportionment of the CU to NU and DU is calculated on the basis of the weight percents of ^{235}U and ^{238}U for NU and DU as stated above.

Substituting the known fractions contributed by DU–235, DU–238, NU–235, NU–238, yields

$$\frac{M(CU-235)}{M(CU-238)} = \frac{\mu \bullet 0.002 + (1-\mu) \bullet 0.00726}{\mu \bullet 0.998 + (1-\mu) \bullet 0.99274} .$$

After multiplying through and rearranging, we obtain

$$\frac{M(CU-235)}{M(CU-238)} = \frac{0.00726 - 0.00526\mu}{0.99274 + 0.00526\mu} .$$

Finally, solving for μ, we find

$$\mu = \frac{0.00726 - 0.99274\dfrac{M(CU-235)}{M(CU-238)}}{0.00526\dfrac{M(CU-235)}{M(CU-238)} + 0.00526} \quad .$$

This is the desired relation for the fraction of total uranium that is contributed by Lab operations, expressed as a function of the measured (by air sampling) ratio of U-235 to U-238 for total (composite) uranium in air; μ for 1993 is 0.4, for 1994 is 0.5, for 1995 is 0.3.

Using these calculations to apportion the M(CU), we obtain an annual average concentration of DU in air from resuspension of 3.15×10^{-11} g/m^3 for 1993, 4.79×10^{-11} g/m^3 for 1994, and 1.58×10^{-11} g/m^3 for 1995.

Eliminating Double Counting: Our previous estimates of the dose to the SW-MEI from resuspended uranium at Site 300 were unnecessarily conservative for another reason besides our assumption that $\mu = 1$. We engaged in double counting, by allowing the depleted uranium from explosives experiments to contribute to the dose first as a direct release into the air during the detonation and subsequent dispersal in air, and then again as a resuspension product when wind disturbs the soil where this uranium has deposited.

To approximately correct for this double counting, we eliminate, when evaluating the observed U-235 to U-238 ratio, all months in which explosives experiments involving depleted uranium occurred. Thus, for 1993 data the months of April, August, September, and November would be excluded; for 1994, data from the months of April, May, September, October, and December would be excluded; and for 1995, the months of March, April, May, June, and August would be excluded. With these months excluded, μ for 1993 remains 0.4, while for 1994 it is reduced to 0.09, and for 1995 it is reduced to 0.1.

Using these calculations to apportion the M(CU) for 1993, and excluding the appropriate months, we obtain an annual average concentration of DU in air from resuspension of 1.83×10^{-11} g/m^3. Similarly, using these calculations for 1994, and excluding months when experiments involving depleted uranium occurred, we obtain an annual average concentration of DU in air from resuspension of 3.41×10^{-12} g/m^3. Finally, applying these calculations, and excluding the appropriate months, we obtain an annual average concentration of DU in air from resuspension of 7.01×10^{-12} g/m^3.

Using the fractions 0.998, 0.002, and 0.000005 to represent the amounts of ^{238}U, ^{235}U, and ^{234}U; specific activities of 3.32×10^{-7}, 2.13×10^{-6}, and 6.16×10^{-3} for ^{238}U, ^{235}U, and ^{234}U; a yearly inhalation rate of 8400 m^3/y, and dose conversion factors from EPA Regulatory Guide 11 of 1.18×10^{-11}, 1.23×10^{-11}, 1.23×10^{-11}, we obtain a total dose for resuspended DU of 6.72×10^{-3} mrem for 1993 as compared to 2.62×10^{-2} mrem reported in the 1993 NESHAPs report, which was based on the total amount of uranium measured in air. Performing identical calculations for 1994, yields a total dose for resuspended DU of 1.25×10^{-3} mrem as compared to 3.2×10^{-2} mrem reported in the 1994 NESHAPs report. Using these dose equations to determine the dose from resuspension for DU, and the modified equations discussed above, we obtained a dose of 2.57×10^{-3} mrem for 1995.

Total Dose Estimate and Comparison with Previous Years' Data

For the Livermore site, the dose calculated for the SW-MEI from diffuse emissions in 1995 was 0.022 mrem (0.22 μSv). When point and diffuse sources were combined, the total annual dose was 0.041 mrem (0.41 μSv). Therefore, the relative contributions to the total were 54% from diffuse sources and 46% from point source emissions. The total dose to the Site 300 SW-MEI from Site 300 operations in 1995 was 0.023 mrem (0.23 μSv). Point-source emissions from firing-table explosives experiments accounted for 0.020 mrem (0.20 μSv), or 87%, of this total, while 0.003 mrem (0.03 μSv), or 13%, was contributed by a diffuse source representing resuspension of LLNL-contributed uranium in surface soils throughout the site. Diffuse-source contributions to dose from tritium emissions remained negligible. Table 4 presents the facilities or sources that account for 90% or more of the doses for the Livermore site or Site 300 SW-MEI.

Comparison of the 1995 total dose estimate with that of previous years can be made by reviewing the information presented in Table 5. No diffuse emissions were reported at Site 300 for years before 1993, so comparison for total dose can only be made with the values for 1993 and 1994; in addition, diffuse source doses were not reported separately from the total dose for the Livermore site for 1990 and 1991. The reduced point source contribution to dose for the Livermore site for 1995 compared to 1994 is attributed to the low level of operations at the Building 513 stabilization unit in 1995 as compared to 1994. The reduced diffuse source contribution to dose for Site 300 is caused by the improved calculations for determining the contribution of resuspended depleted uranium to dose; these calculations were discussed in the diffuse source dose section.

Table 4. List of facilities or sources whose emissions account for 90% or more of the doses for the Livermore site and Site 300 SW-MEI.

Facility or Source	Dose (mrem)	Percent Contribution to Total Dose
Livermore site		
Building 331	0.017	41%
Building 612 Area Source	0.014	34%
Building 331 Area Source	0.0059	14%
Building 231	0.0013	3%
Site 300		
801 Firing Table	0.012	53%
851 Firing Table	0.0082	34%
Soil Resuspension	0.0026	11%

Table 5. Doses (in mrem) calculated for the Site-Wide Maximally Exposed Individual for the Livermore site and Site 300, 1990 to 1995.

Year	Total Dose	Point Source Dose	Diffuse Source Dose
Livermore site			
1995	0.041	0.019	0.022
1994	0.065	0.042	0.023
1993	0.066	0.040	0.026
1992	0.079	0.069	0.010
1991	0.234	—[a]	—[a]
1990	0.240	—[a]	—[a]
Site 300			
1995	0.023	0.020	0.003
1994	0.081	0.049	0.032
1993	0.037	0.011	0.026
1992	0.021	0.021	—[b]
1991	0.044	0.044	—[b]
1990	0.057	0.057	—[b]

[a]Diffuse source doses were not reported separately from the total dose for the Livermore site for 1990 and 1991.

[b]No diffuse emissions were reported at Site 300 for years before 1993.

SECTION V. Certification

I certify under penalty of law that I have personally examined and am familiar with the information submitted herein, and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Name: James Hirahara
U.S. Department of Energy
Oakland Operations Office
1301 Clay Street; Room 700N
Oakland, CA 94612

Signature: _____ **Date:** _____
James Hirahara

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Name: Dennis K. Fisher
Associate Director
Plant Operations
Lawrence Livermore National Laboratory
7000 East Avenue
Livermore, CA 94551

Signature: _____ **Date:** _____
Dennis K. Fisher

SECTION VI. Supplemental Information

Collective Effective Dose Equivalent

Population doses, or collective EDEs, for both LLNL sites were calculated out to a distance of 80 km in all directions from the site-centers using CAP88-PC. As noted earlier, CAP88-PC evaluates the four principal exposure pathways: ingestion through food and water consumption, inhalation, air immersion, and irradiation by contaminated ground surface.

Population distributions centered on the two LLNL sites were compiled from 1990 census data. Key population centers affected by LLNL emissions are the relatively nearby communities of Livermore and Tracy, and the more distant metropolitan areas of Oakland, San Francisco, and San Jose, as well as the San Joaquin Valley communities of Modesto and Stockton. Within the 80 km outer distance specified by the EPA, there are 6.3 million residents included for the Livermore site collective dose determination, and 5.4 million for Site 300. Our population data files (distribution of population with distance and direction) are shown in Tables 6 and 7 for the Livermore site and Site 300, respectively.

Table 6. Population distribution for LLNL's Livermore site, based on 1990 census information. Values are population (in thousands) in sector segments bounded by the indicated inner and outer radii, for each of sixteen 22.5-degree-sector directions.

	Range of distance from site (km)					
Direction	0-16	16-32	32-48	48-64	64-80	Total
N	17	15	121	25	15	**193**
NNW	17	16	173	149	46	**401**
NW	17	53	136	291	17	**514**
WNW	27	13	509	715	232	**1496**
W	28	167	146	211	3	**555**
WSW	27	222	319	19	7	**594**
SW	27	58	199	50	49	**383**
SSW	7	44	700	82	99	**932**
S	7	6	7	111	47	**178**
SSE	7	10	7	10	11	**45**
SE	7	7	6	10	18	**48**
ESE	7	9	8	74	145	**243**
E	7	8	82	22	38	**157**
ENE	7	7	48	169	16	**247**
NE	7	11	10	63	78	**169**
NNE	17	22	6	7	74	**126**
Total	**233**	**668**	**2477**	**2008**	**895**	**6281**

Table 7. Population distribution for LLNL's Site 300, based on 1990 census information. Values are population (in thousands) in sector segments bounded by the indicated inner and outer radii, for each of sixteen 22.5-degree sector directions.

	Range of distance from site (km)									
Direction	0-15	15-24	24-32	32-42	42-50	50-57	57-63	63-74	74-80	Total
N	2.3	1	10	1	3.5	3.5	38	36	1	**96**
NNW	2.3	10	22	6	81	40	25	8	7	**201**
NW	2.3	1	8	33	13	80	80	149	23	**389**
WNW	3.5	32	32	33	33	70	220	400	510	**1334**
W	3.5	14	54	55	83	84	73	73	105	**545**
WSW	3.5	14	14	30	250	100	320	125	42	**899**
SW	3.5	1	1	28	22	350	350	82	50	**888**
SSW	2	1	10	7	4	3	55	55	47	**184**
S	2	1	4	2	1	10	5	6	1	**32**
SSE	2	1	5	3	8	6	12	1	1	**39**
SE	0.1	5	23	54	1	1	1	1	1	**87**
ESE	0.1	1	1	1	73	72	1	1	1	**151**
E	0.1	72	11	11	38	1	1	1	1	**136**
ENE	0.1	10	1	1	8	8	1	1	1	**31**
NE	0.1	30	18	169	1	1	1	1	1	**222**
NNE	1	1	1	32	31	1	78	1	1	**147**
Total	**28**	**195**	**215**	**466**	**651**	**831**	**1261**	**941**	**793**	**5380**

For the evaluation of the population dose, as distinct from the individual dose, all food (and in particular milk) was assumed to be produced locally. This decision was made because, although there are no commercial dairy animals within the distances used to evaluate individual doses, many dairy animals live within 80 km of the Livermore site and Site 300.

The collective EDE due to 1995 Livermore-site operations was 0.59 person-rem (0.0059 person-Sv), of which 0.38 person-rem (0.0038 person-Sv), or 64%, was from point-source emissions, and the remaining 36% from diffuse sources. This value is slightly less than the 1994 result of 0.76 person-rem (0.0076 person-Sv).

The corresponding collective EDE from Site 300 operations in 1995 was 7.7 person-rem (0.077 person-Sv), of which 7.2 person-rem (0.072 person-Sv), or 94%, was due to point-source emissions, and 0.5 person-rem (0.005 person-Sv) was from diffuse-source emissions. The total collective EDE value is less than half the 1994 value of 17 person-rem (0.17 person-Sv), but is very similar to the 1993 value of 6.9 person-rem (0.069 person-Sv). These differences are

the result of differences in the amounts of high explosives and depleted uranium used each year in explosives experiments.

The larger value for Site 300 compared to the Livermore site is traceable primarily to the highly conservative assumptions about the Site 300 explosives experiments, especially regarding the fraction of radioactive material that is aerosolized and the height and trajectory of the explosive-debris cloud. This conservative modeling methodology over-predicts the quantity of radionuclides released to air by at least a factor of five, we believe, and over-estimates the long-range dispersal of material in these experiments. In 1992, we submitted to EPA a modeling protocol designed to treat the transient explosive experiments more realistically than does CAP88-PC, but this protocol was not accepted.

We again note that the diffuse sources influence the individual dose to the SW-MEI more than they affect the population dose. The reason is the relatively less dynamic nature of the diffuse-source emissions, originating low to the ground at low initial velocity. Stacks release effluents at considerable speed high above the ground, and the explosives experiments force the effluent high into the air, allowing contaminants to be more readily transported toward population centers downwind.

Compliance with 40 CFR 61 Subpart H (61.93)

Calculations of effective dose equivalents for all Livermore-site and Site 300 facilities having the potential to release radionuclides to the atmosphere have been completed. Annual doses from actual total emissions of all facilities during 1995 were found to be well below the 10 mrem (100 μSv) NESHAPs dose standard. Tritium accounted for most of the Livermore-site calculated dose, while at Site 300 practically the entire calculated dose was due to the isotopes ^{238}U, ^{235}U, and ^{234}U, in depleted uranium.

Based on potential emissions without control devices and consensus with the EPA, 17 emission points in three facilities at the Livermore site will maintain continuous monitoring systems in compliance with NESHAPs requirements. Continuous monitoring will be maintained in Building 332 and the hardened area of Building 251 instead of a modeling or measurement effort to demonstrate the actual need for monitoring. Continuous monitoring is being continued at Building 331 even though the EDEs that result from measured emissions do not require monitoring under 40 CFR 61.93(b).

Several other Livermore-site facilities (Buildings 175, 231, 251 Unhardened, 419, 490, and 491) also will maintain continuous-monitoring systems; however, calculations using unabated potential emissions resulted in EDEs of less than 0.1 mrem/y (1 μSv/y) for the emissions from each of these facilities. While this monitoring also will be continued, it is not required under NESHAPs.

For facilities having discharge points without continuous monitoring, the requirement for continuous monitoring was individually evaluated. The evaluation was based on unabated emissions, even if emission-control systems existed. No additional facilities at either LLNL site were found to require continuous monitoring.

Status of compliance with 40 CFR 61 Subpart Q - National Emission Standards for Radon Emissions from Department of Energy Facilities

LLNL does not have storage and disposal facilities for radium-containing materials that would be a significant source of radon.

Status of compliance with 40 CFR 61 Subpart T - National Emission Standards for Radon Emissions from the Disposal of Uranium Mill Tailings

LLNL does not have or store any uranium mill tailings.

Information on Radon-220 and Radon-222 Emissions

The majority of radon sources at LLNL occur naturally by emanation from the earth. Radon-222 emissions from research experiments during 1995 were estimated to be 0.24 μCi (8.9×10^3 Bq) with a corresponding EDE of 7×10^{-13} mrem (7×10^{-12} μSv). Very few experiments using ^{222}Rn were conducted in 1995, leading to a much smaller emission estimate for 1995 than for 1994. These ^{222}Rn emissions are less than one-hundred-millionth of that expected for naturally occurring ^{222}Rn emanation from the soil of the LLNL site.

Upgrades to Existing Sampling Systems

We have completed upgrades to existing sampling systems located in facilities that have been identified as requiring monitoring of emission points according to NESHAPs. These are Building 331, Building 332, and the hardened portion of Building 251. The upgrades included the installation of multi-port aerosol extraction probes, minimization of sample transport line

length, and relocation of some samplers to meet certain location requirements for sample extraction. The upgrades will ensure the extraction of representative samples as specified by the ANSI N13.1-1969 guidelines called for by 40 CFR 61 Subpart H.

In addition to the sampling system upgrades, anemometer-type, multi-port velocity probes were designed, fabricated, and installed at the sampling locations. These were calibrated using procedures in 40 CFR 60 Appendix A. The velocity probes provide for continuous and near real-time measurement of the exhaust flow from the discharge points. In all, the upgrades involved modifications to 19 aerosol sampling systems and the installation of 21 velocity probes.

These upgrades took three years to complete at a cost of $950,000.

Site Periodic Confirmatory Measurements

LLNL uses a graded approach to determine the required level of periodic confirmatory measurements. The greater the calculated EDE, the more intensive the measurements will be. LLNL invokes a four-tier approach: (1) continuous monitoring at selected facilities, (2) annual effluent sampling, (3) general surveillance monitoring, and (4) site-specific surveillance monitoring, as described below.

Continuous Monitoring: There are currently nine buildings (Buildings 166, 175, 231, 251, 331, 332, 419, 490, and 491) at the LLNL site that have radionuclide air-monitoring systems. These buildings are listed in Table 8, along with the number of samplers, the types of samplers, the analytes of interest, and the number of monitored discharge points at the building. In all, there are 103 samplers operating continuously. Many would operate from emergency power systems if normal power were lost.

In 1995, a new sampling system was installed at Building 166, the Pyrochemistry Demonstration Facility, to continuously sample for potential emissions of uranium particles. Before operations began, a NESHAPs assessment was performed. Results indicated that the MEI resulting from estimated emissions (assuming no control devices) exceeded 0.1 mrem/y (1.0 μSv/y), and therefore required continuous sampling. The sampler was installed in the exhaust from glove boxes where the operations are performed. Operations are HEPA filtered.

Table 8. Air-effluent sampling locations and systems.

Building	Facility	Analytes	Sample type	Number of samplers	Number of discharge points
166	Pyrochemical Demonstration Facility	Gross α, β on particles	Filters	1	1
175	MARS	Gross α, β on particles	Filters	6	6
231	Vault	Gross α, β on particles	Filter	1	1
251	Heavy Elements				
	Unhardened area	Gross α, β on particles	Filters	44	55[a]
	Hardened area	Gross α, β on particles	Filters	4	4
	Hardened area	Gross α, β on particles	CAM[b]	4	4
331	Tritium	Tritium	Ionization Chamber[b]	4	4
		Gaseous tritium/ tritiated water vapor	Molecular sieves	4	2
332	Plutonium	Gross α, β on particles	CAM[b]	12	11
		Gross α, β on particles	Filters	16	11
419	Decontamination	Gross α, β on particles	Filters	2	2
490	USEC Laser Isotope Separation	Gross α, β on particles	Filters	4	4
491	USEC Laser Isotope Separation	Gross α, β on particles	Filters	1	1

Note: "CAM" denotes Eberline continuous air monitors.
[a] Alternate blower system measured by the same sampler.
[b] Alarmed systems.

Air samples for particulate emissions are extracted downstream of HEPA filters and prior to the discharge point to the atmosphere. Particles are collected on membrane filters. The sample filters are removed and analyzed for gross alpha and beta activity on a weekly or bi-weekly frequency depending on the facility. In most cases, simple filter-type aerosol collection systems are used. However, in some facilities, alpha continuous-air monitors (CAMs) are used for sampling. In addition to collecting a sample of particles,

the CAM units provide an alarm capability for the facility in the event of a release of alpha activity.

Detection of gross alpha and beta activity resulting from particles collected on the air filters is accomplished using gas-flow-proportional counters. Analysis is delayed for at least four days from sample termination to allow for the decay of naturally occurring radon daughters. For verification of the operation of the counting system, calibration sources, as well as background samples, are intermixed with the sample filters for analysis. Analysis is performed by the Radiological Measurements Laboratory (RML) in the Hazards Control Department (HCD).

Each stack of the Tritium Facility (Building 331) is monitored for tritium release by both a continuous-monitoring alarm system and continuous molecular-sieve samplers. The alarmed samplers, Overhoff ion chambers, provide real-time tritium concentration release levels (HT and HTO). The sieve samplers, which can discriminate between tritiated-water (HTO) vapor and molecular tritium (HT), provide the values used for environmental reporting and are exchanged weekly or bi-weekly depending on the rate of tritium releases expected from planned work. Each sieve sampler (unalarmed) is in parallel with an alarmed monitor and consists of two molecular sieves. The first sieve collects tritiated water vapor; then a palladium-coated catalyst converts molecular tritium to tritiated water, which is then collected on a second sieve. The molecular sieve samples are submitted to the Hazards Control Analytical Laboratory where they are installed into a recovery system for the bake-out of tritiated-water vapor and subsequent condensation and collection of the water. The retrieved tritiated water is analyzed by RML using liquid-scintillation counting techniques. New continuous air-effluent-flow-measurement systems were installed as part of the efforts previously discussed in the stacks of the Tritium Facility.

Data from air-particulate-sampling filter and molecular-sieve analyses are reviewed by the Hazards Control Department Health Physicist responsible for each facility and an Environmental Protection Department Environmental Analyst.

Annual Effluent Sampling: For point sources where the fence line EDE is between 0.1% and 1% of the NESHAPs emission standard of 10 mrem/y (100 μSv/y) (between 0.01 and 0.1 mrem/y or 0.1 and 1.0 μSv/y), and no existing monitoring system is in place, LLNL strives to perform annual confirmatory sampling. Measurements of the effluent from such sources are planned for the year following the annual dose assessment. These

measurements are planned to be taken downstream of any emission control devices and when operations are being performed. Four facilities at LLNL fit into this EDE range during 1994 for monitoring in 1995: Building 177, Building 231, Building 513, and Building 514. Lack of operations at three of the facilities in 1995 prohibited any confirmatory monitoring. However, monitoring was conducted at Building 514.

The operation sampled at Building 514 was the Dorr-Oliver Rotary Drum Vacuum Filtration Unit. This process involves shaving layers of low-level radioactive sludge originating at the Hazardous Waste Management Building 514 Tank Farm that has been mixed with diatomaceous earth. The layers are collected into drums, which are then sealed. The Filtration Unit ran for 90 days during 1995 at an average run time of 6.5 hours a day. Room air ventilation consisted of a stand up fan, wall-mounted exhaust fan, and open doors. The ambient room air was sampled using a High-Volume Particulate Sampler that pulled air through a cellulose ashless filter paper at a constant flow rate of 550 L/m. The sampler was approximately 3 meters away from the filtration unit.

The first sampling event ran for a total of 24.5 hours. The sampling unit was turned on at the start of operations and off after the operations were completed; the sampling unit was only run during the filtration unit's operation. The sampling unit was inspected twice daily and the flow rate was verified using a calibration unit. The second sample was collected when the filtration unit was not operating. The sampler was operated for 22.5 hours with a verified flow rate of 550 L/m.

Analysis of the filters indicated a ^{235}U concentration of 3.12×10^{-6} $\mu g/m^3$ and a ^{238}U activity of 6.99×10^{-4} $\mu g/m^3$ during filtration unit operations. When the filtration unit was not operating, a ^{235}U concentration of 6.26×10^{-6} $\mu g/m^3$ and a ^{238}U concentration of 1.57×10^{-4} $\mu g/m^3$ were found. Doses calculated to a person working at the filtration unit, using EPA Federal Guidance Report No. 11 (Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors For Inhalation, Submersion, And Ingestion, EPA 520/1-88-020) dose conversion factors and an inhalation rate of 560 m^3/y for the 90 days of operation at 6.5 hours per day and an inhalation rate of 1510 m^3/y for the 17.5 hours per day when the unit was not running during the 90 days of operation, yields an annual dose of 0.09 mrem/y (0.9 $\mu Sv/y$). Any dose to a person off site would be considerably lower, confirming that continuous monitoring is not required.

General Surveillance Monitoring: Surveillance air monitoring for tritium and radioactive particles has been in place since the 1970s and will continue. LLNL currently maintains eight continuously operating, high-volume, air-particulate samplers on the Livermore site, nine in the Livermore Valley, eight at Site 300, and one in Tracy. LLNL also maintains eleven continuously operating airborne-tritium samplers on the Livermore site and five samplers in the Livermore Valley. The samplers are positioned to ensure reasonable probability that any significant airborne concentration of particulate and tritium effluents resulting from LLNL operations will be detected. The data from this monitoring network provide continuous measurements of the concentrations of radionuclides present in the air at the Livermore site, Site 300, and in the surrounding areas. This network allows for direct measurements of the overall impact of LLNL operations. Data from this network are presented in the Site Annual Environmental Report (Harrach et al., Environmental Report for 1994, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-50027-94).

Site-Specific Surveillance Monitoring: Surveillance air monitors are placed near diffuse emission sources, such as those associated with Buildings 292, 331, 514, and 612, as well as in and around the Southeast Quadrant of the Livermore site. The data from these monitoring networks provide continuous measurements of the concentrations of specific radionuclides present in the air near these sources and allow a direct and accurate determination of their environmental impact. This practice will continue at these locations. It has been determined that the use of site-specific surveillance monitoring for Site 300 diffuse sources of tritium is unnecessary because of the low emissions and resultant dose values displayed in Attachment 1.

Status of the NESHAPs QA Program

The LLNL NESHAPs Quality Assurance (QA) Program is a multi-organizational effort that relies on the Quality Assurance/Quality Control programs that are in place at the LLNL facilities with continuous air-monitoring systems, the Radiological Measurements Laboratory (RML) of the Hazards Control Department, and the Environmental Protection Department (EPD).

Facility Safety Procedures (FSPs), Safety Analysis Reports (SARs) and QA Manuals for each monitored facility describe its organizational structure, responsibilities for sampling locations used for continuous air monitoring, and the procedures to be followed in the case of unplanned radionuclide

releases. For example, the FSP for the Plutonium Facility (Building 332) describes in detail the procedure for responding to detection of radioactive materials in a release from the stacks. These documents also describe the sample-collection systems for both continuous and passive (i.e., not alarmed) air-monitoring systems (CAM and PAM, respectively), including sampling probes and procedures to be used for measuring flow rates, sampling, and calibration. Similarly, the FSP for the Tritium Facility (Building 331) describes its stack monitoring system, which includes molecular-sieve detectors for tritiated water (HTO) and elemental tritium gas (HT).

The RML Quality Assurance Program describes laboratory-analysis procedures, precision, accuracy and completeness objectives, sample-tracking procedures, quality-control (QC) sampling, sample handling, and data reporting. For example, the Gross Alpha-Beta Procedures Manual of the RML describes operational procedures for analyzing the CAM and PAM filters for radioactivity.

EPD, which is responsible for NESHAPs modeling and reporting, also operates under a Quality Assurance Management Plan and associated procedures. Detailed records are kept of all measurements, model runs, and calculations, and selected model runs are validated. The Terrestrial and Atmospheric Monitoring and Modeling Group (TAMM) of EPD is responsible for modeling and reporting radionuclide emissions for NESHAPs compliance. TAMM members continue to refine mechanisms that ensure they are informed whenever new operations are proposed, significant changes in radionuclide inventories occur, or existing operations are modified so that NESHAPs modeling can be performed and appropriate action taken. All NESHAPs calculations are archived with the supporting information used to make the calculations.

Quality Control (QC) for 1995 Radiological Inventory Update and Modeling

Radiological Inventory Update QC: Approximately 15% of the 21 Livermore-site facilities that completed radiological-inventory updates in 1995 were randomly selected for validation. For this QC check, radiological inventories from four potential emission points were selected for validation: one each in Buildings 222, 253, 327 and 362. An EPD Environmental Analyst contacted the responsible party who signed the NESHAPs Inventory Forms and physically visited and inspected the facilities to verify inventory data. The responsible party was asked to demonstrate how he/she arrived at the data submitted on the original inventory form. Stack parameters also were verified. The QC data

were compared to the original data. The accuracy of the inventory data was confirmed.

Modeling QC: Fifteen percent of the CAP88-PC modeling runs were selected for validation by a second analyst using a different computer and copy of CAP88-PC. The analyst performing this QC effort ran the model following independent gathering of radionuclide inventories and stack data from the NESHAPs Inventory Forms and pertinent distances from site maps. The QC modeling verified the values from the original CAP88-PC modeling runs. The data that are presented in the attached spreadsheet are as accurate as possible, demonstrating that quality objectives are being met.

Attachment 1. 1995 LLNL NESHAPs Annual Report Spreadsheet

Guidance for Interpreting Attachment 1

A generalized description of each facility and its operations is provided on the spreadsheet. In addition, the following information is shown for each listed emission point or stack:

- Building and room number(s)
- Specific stack identification code(s)
- Generalized operations in the room(s) or area(s)
- Radionuclides utilized during 1995
- Annual radionuclide inventory with potential for release (by isotope, in curies)
- Physical-state factors (by isotope)
- Stack parameters
- Emission-control devices and emission-control-device abatement factors
- Estimated or measured annual emissions (by isotope)
- Distance and direction to the site-wide maximally exposed individual (SW-MEI)
- Calculated EDE to the SW-MEI
- Distance and direction to the maximally exposed individual for that specific source (MEI)
- Calculated EDE to the MEI (source term not adjusted for emission controls)
- Source category
- Below Appendix E Quantity (Y or N)

Radionuclides: The radionuclides shown in the spreadsheet are those from specific emission points where air emissions were possible. If radionuclides were present, but encapsulated or sealed for the entire year, radionuclides, annual inventories, and emissions are not listed.

For Building 231, Room 1128 (a Materials Management vault that is used for receipt, shipment, and storage of sealed radioactive sources), the variety and turnover of radionuclides makes a listing of individual radionuclides and their inventories impractical. This area is continuously monitored, and emissions are therefore directly determined.

Radionuclide Inventories with Potential for Release: The annual radionuclide inventories for point-source locations are based on data from

facility experimenters and managers. For Buildings 251 (hardened area) and 332, classification issues regarding transuranic-radionuclide inventories make use of the inventory/modeling approach impractical. However, all such affected emission points in these buildings are continuously monitored, and emissions are therefore directly determined. LLNL conducted a complete radionuclide-inventory update in 1994. Because of the magnitude of effort required to complete a site-wide inventory, the 1995 inventory was conducted for all new sources and for those sources that cumulatively contributed to 90% or more of the dose for 1994.

Physical-State Factors: The physical-state factors listed are EPA potential-release fractions from 40 CFR 61, Appendix D, whereby emissions are estimated from radionuclide inventories depending on their physical states for use in dispersion/dose assessment modeling. A physical-state factor of 1.0×10^{-6} is used for solids, 1.0×10^{-3} is used for liquids and powders, and 1.0 is used for unconfined gases.

Stack Parameters: Engineering surveys conducted from 1990 through 1992 form the basis for the stack physical parameters shown, which were checked and validated by facility experimenters and managers for 1994. Stack physical parameters for new sources in 1995 were provided by experimenters and managers for those facilities.

Emission-Control Devices: High-Efficiency-Particulate-Air (HEPA) filters are used in many LLNL facilities to control particulate emissions. For some discharge points, scrubbers and electrostatic precipitators aid the control of emissions. The operational performance of all HEPA filtration systems is routinely tested. The required efficiency of a single-stage HEPA filter is 99.97%. Double-staged filter systems are in place on some discharge points. Triple-stage HEPA filters are used on glove-box ventilation systems in the Building 332 Plutonium Facility and in the hardened portion of Building 251.

Control-Device Abatement Factors: Similar to physical-state factors, control-device abatement factors, from Table 1 in 40 CFR 61, Appendix D, are those associated with the listed emission-control devices, and are used to better estimate actual emissions for use in dispersion and dose models. By regulation, each HEPA filter stage is given a 0.01 factor (even though the required test efficiency that all LLNL HEPA filters must maintain would yield a factor of 0.0003), venturi scrubbers and electrostatic precipitators are each given a 0.05 factor, and each activated-charcoal filter is given a 0.1 factor.

Estimated Annual Emissions: For unmonitored and non-continuously monitored sources, estimated annual emissions for each radionuclide are based on the product of (1) inventory data, (2) EPA potential-release fractions (physical-state factors), and (3) applicable emission-control-device abatement factors.

Actual emission measurements are the basis for reported emissions from continuously monitored facilities. LLNL facilities that have continuous monitoring systems are Buildings 166, 175, 231-vault, 251, 331, 332, 419, 490, and 491. See page 9 for a discussion of the use of emissions measurements for monitored sources.

10 mrem/y Site-Wide Dose Requirement: For LLNL to comply with the NESHAPs regulations, the LLNL site-wide maximally exposed individual (SW-MEI; defined as the hypothetical member of the public at a single residence, school, business, or office who receives the greatest LLNL-induced EDE from the combination of all radionuclide source emissions) cannot receive an EDE greater than 10 mrem/y (100 μSv/y).

In Attachment 1, the distance and direction to the respective SW-MEI are shown for each facility at each site. Doses to the site-specific SW-MEIs were evaluated for each source and then totaled for site-specific evaluations against the 10 mrem/y dose standard (see "Compliance Assessment" in Section III).

0.1 mrem/y Monitoring Requirement: To assess compliance with the requirement for continuous monitoring (potential dose greater than 0.1 mrem/y [1.0 μSv/y]), emissions must be individually evaluated from each point source; the location of the maximally exposed public individual (MEI) is generally different for each emission point. The maximum dose at a location of unrestricted public access typically occurs at a point on the site perimeter. Therefore, it is often referred to as the maximum "fence line" dose, although the off-site maximum dose could occur some distance beyond the perimeter. (This could happen, e.g., when the perimeter is close to a stack; however, for all emission points at the Livermore site and Site 300, calculations show that ground-level concentrations of radionuclides decline monotonically beyond LLNL boundaries.) As stipulated by the regulations, modeling for assessment of continuous monitoring requirements assumed unabated emissions (i.e., no credit was taken for emission abatement devices, such as filters), but physical-state factors were applied.

The unabated EDE cannot be calculated for monitored facilities. Because the monitoring equipment is placed after HEPA filtration, there is no way to

obtain an estimate for what the emissions might have been had there been no filtration. It is not reasonable to apply factors for the effects of the HEPA filters on the emission rate because most of what is measured on the HEPA filters is the result of the radioactive decay of radon, which is capable of penetrating the filter. Attachment 1 gives, for each inventoried point source, the dose to the MEI and the distance and direction to the LLNL fence line where the MEI is located. However, for monitored sources, no value is shown.

Source Categories: LLNL radionuclide air-emission sources have been classified into six source categories, indicated by the number in the next to last column of the spreadsheet: (1) Unmonitored or non-continuously monitored Livermore-site facilities that have had a radionuclide-inventory update for 1995; (2) Unmonitored or non-continuously monitored Livermore site facilities with a previous (1994) radionuclide-inventory update; (3) Continuously monitored Livermore-site facilities; (4) Site 300 explosives experiments; (5) Diffuse sources where emissions and subsequent doses were estimated using inventory processes; and (6) Diffuse sources where emission and dose estimates were supported by environmental-surveillance measurements.

Below Appendix E Quantity: In 1995, DOE and EPA entered into a memorandum of understanding that, among other things, made the contents of 40 CFR 61, Appendix E acceptable "other procedures" for DOE facilities to establish compliance with Section 61.93(a) of Subpart H. Part of Appendix E is a list of "Annual Possession Quantities for Environmental Compliance." Facilities having less than these quantities of radionuclides need not report to EPA under NESHAPs. A letter "Y" in this column denotes those inventoried sources at LLNL facilities that contain radionuclides in amounts below the annual possession quantities listed in Appendix E.

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category	Below App. E Quantity
NOTE: CAP88-PC requires activity rates of curies/year and gives doses in mrem/year. To convert curies to becquerels use 1 Ci=3.7E+10 Bq and to convert millirem to sieverts use 1 Sv=1.0E+05 mrem.																				
LIVERMORE SITE POINT SOURCES																				
Building 131 complex is a large office/laboratory facility housing both Mechanical Engineering and Electrical Engineering Division.																				
131	Vault	Room Air	Temporary Storage	U-238	3.5E-07	1.0E-06	NA	NA	NA	None	1	3.5E-13	1326	E	1.6E-11	559	SW	8.0E-11	2	Y
				U-235	4.6E-09	1.0E-06						4.6E-15								Y
				U-234	3.3E-08	1.0E-06						3.3E-14								Y
131	1221	Room Air	Temporary Storage	U-238	8.3E-02	1.0E-06	NA	NA	NA	None	1	8.3E-08	1326	E	4.6E-06	383	SSW	9.7E-05	2	Y
				U-235	1.1E-03	1.0E-06						1.1E-09								Y
				U-234	7.7E-03	1.0E-06						7.7E-09								Y
131	Hi-Bay Rooms	131-Hi-Bay-FEV	No Operations	None	None	NA	10.7	1.00	3.0	HEPA	0.01	0.0E+00	1326	E	0.0E+00	NA	NA	0.0E+00	2	Y
	1331, 1341																			
	1341A, 1345																			
	1345A, 1349																			
131	2250	Room Air	Processing systems	U-238	3.3E-01	1.0E-06	NA	NA	NA	None	1	3.3E-07	1326	E	1.8E-05	383	SSW	3.9E-04	2	Y
				U-235	4.3E-03	1.0E-06						4.3E-09								Y
				U-234	3.1E-02	1.0E-06						3.1E-08								Y
Building 151 houses the Isotope Sciences Division which applies nuclear and isotope sciences to a wide range of problems, including stockpile stewardship, nonproliferation, safeguard technologies, forensic science, and waste characterization and analysis.																				
Building 151 also contains the Chemistry and Materials Sciences Environmental Services laboratory (room 2117) where samples of waste streams and environmental media (air, water, soil etc.) are analyzed for their radionuclide content.																				
151	1039	FHE-04	Aliquiot Extraction	Sr-90	2.0E-08	1.0E-03	19.2	0.41	16.4	None	1	2.0E-11	1308	E	3.4E-11	1125	NNE	8.7E-11	2	Y
				Ru-106	3.0E-10	1.0E-03						3.0E-13								Y
				Cs-137	3.0E-08	1.0E-03						3.0E-11								Y
				Ce-144	3.0E-10	1.0E-03						3.0E-13								Y
				Pm-147	1.0E-08	1.0E-03						1.0E-11								Y
151	1043	FGBE-19/20	Core Dissolution	Sr-90	2.7E-08	1.0E-03	8.4	0.21	13.1	Scrubber and	0.0025	6.8E-14	1308	E	1.3E-13	586	WSW	1.7E-10	2	Y
				Ru-106	3.2E-10	1.0E-03				Precipitator		8.0E-16								Y
				Cs-137	3.4E-08	1.0E-03						8.5E-14								Y
				Ce-144	3.2E-10	1.0E-03						8.0E-16								Y
				Pm-147	1.0E-08	1.0E-03						2.5E-14								Y
151	1133	FHE-48	Sample Analysis	Am-241	1.0E-10	1.0E-03	19.2	0.41	4.7	None	1	1.0E-13	1308	E	7.2E-10	1125	NNE	2.1E-09	2	Y
				Pu-239	3.0E-09	1.0E-03						3.0E-12								Y
				Pu-240	6.0E-10	1.0E-03						6.0E-13								Y
				U-235	3.0E-11	1.0E-03						3.0E-14								Y
				U-238	3.0E-10	1.0E-03						3.0E-13								Y
				Pa-231	3.0E-09	1.0E-03						3.0E-12								Y
151	1143	FHE-64	Sample Preparation	Pu-239	2.0E-08	1.0E-03	19.2	0.61	2.8	None	1	2.0E-11	1308	E	4.0E-08	1125	NNE	9.5E-08	1	Y
				U-234	9.0E-07	1.0E-03						9.0E-10								Y
				U-235	3.5E-08	1.0E-03						3.5E-11								Y
				U-238	1.6E-07	1.0E-03						1.6E-10								Y
151	1318	FHE-26	Sample Preparation	Pu-239	1.0E-09	1.0E-03	19.2	0.41	4.9	None	1	1.0E-12	1308	E	1.3E-10	1125	NNE	3.6E-10	2	Y
				Am-241	2.0E-10	1.0E-03						2.0E-13								Y
				Cm-244	1.0E-10	1.0E-03						1.0E-13								Y
				I-129	6.0E-11	1.0E-03						6.0E-14								Y
151	1322	FHE-34	Sample Processing	Sr-90	2.0E-09	1.0E-03	19.2	0.41	4.7	None	1	2.0E-12	1308	E	4.5E-08	1125	NNE	1.3E-07	2	Y
				Ru-106	3.0E-11	1.0E-03						3.0E-14								Y
				Cs-137	3.0E-09	1.0E-03						3.0E-12								Y
				Ce-144	3.0E-11	1.0E-03						3.0E-14								Y
				Pm-147	1.0E-09	1.0E-03						1.0E-12								Y
				Pu-239	2.0E-07	1.0E-03						2.0E-10								Y
				Am-241	2.0E-07	1.0E-03						2.0E-10								Y
151	1326	FHE-43	Sample Analysis	Sr-90	2.0E-09	1.0E-03	19.2	0.41	5.8	None	1	2.0E-12	1308	E	4.5E-08	1125	NNE	1.3E-07	2	Y
				Ru-106	3.0E-11	1.0E-03						3.0E-14								Y
				Cs-137	3.0E-09	1.0E-03						3.0E-12								Y
				Ce-144	3.0E-11	1.0E-03						3.0E-14								Y
				Pm-147	1.0E-09	1.0E-03						1.0E-12								Y
				Pu-239	2.0E-07	1.0E-03						2.0E-10								Y
				Am-241	2.0E-07	1.0E-03						2.0E-10								Y

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory	Physical	Stack	Stack	Stack	Control	Control Device	Estimated	10 mrem/y Site-Wide Dose Requirement			0.1 mrem/y Monitoring Requirement			Source	Below
					with Potential for	State	Height (m)	Diameter	Velocity	Device(s)	Abatement	Annual Emissions	Distance to	Direction	EDE	Distance	Direction	Unabated	Category	App. E
					Release (Ci)	Factor		(m)	(m/s)		Factor	(Ci)	SWMEI (m)	to SWMEI	(mrem)	to MEI (m)	to MEI	EDE (mrem)		Quantity
151	1330	FHE-54	Sample Preparation	U-238	8.0E-08	1.0E-03	19.2	0.41	4.9	None	1	8.0E-11	1308	E	2.4E-09	1125	NNE	6.9E-09	2	Y
151	1334	FHE-61	Sample Processing	Sr-90	1.0E-09	1.0E-03	19.2	0.41	5.5	None	1	1.0E-12	1308	E	2.3E-08	1125	NNE	6.5E-08	2	Y
				Ru-106	1.5E-11	1.0E-03						1.5E-14								Y
				Cs-137	1.5E-09	1.0E-03						1.5E-12								Y
				Ce-144	1.5E-11	1.0E-03						1.5E-14								Y
				Pm-147	5.0E-10	1.0E-03						5.0E-13								Y
				Pu-239	1.0E-07	1.0E-03						1.0E-10								Y
				Am-241	1.0E-07	1.0E-03						1.0E-10								Y
151	2103	FHE-7	Sample Preparation	Co-60	4.0E-06	1.0E-03	19.2	0.41	6.2	None	1	4.0E-09	1308	E	6.8E-09	1125	NNE	1.8E-08	2	Y
151	2107	FHE-14	Tracer Preparation	Pu-239	3.4E-14	1.0E-03	19.2	0.41	6.9	None	1	3.4E-17	1308	E	4.4E-11	1125	NNE	1.3E-10	2	Y
				H-3	1.3E-11	1.0E-03						1.3E-14								Y
				Cs-137	3.6E-14	1.0E-03						3.6E-17								Y
				Sr-90	2.0E-12	1.0E-03						2.0E-15								Y
				Eu-152	3.4E-11	1.0E-03						3.4E-14								Y
				Eu-154	3.4E-11	1.0E-03						3.4E-14								Y
				Ra-226	1.7E-12	1.0E-03						1.7E-15								Y
				Co-60	2.3E-12	1.0E-03						2.3E-15								Y
				Th-232	2.8E-14	1.0E-03						2.8E-17								Y
				Ba-133	4.0E-13	1.0E-03						4.0E-16								Y
				U-238	1.5E-09	1.0E-03						1.5E-12								Y
151	2109	FHE-19	Sample Processing	Sr-90	2.0E-09	1.0E-03	19.2	0.33	5.3	None	1	2.0E-12	1308	E	3.6E-12	1125	NNE	9.6E-12	2	Y
				Ru-106	3.0E-11	1.0E-03						3.0E-14								Y
				Cs-137	3.0E-09	1.0E-03						3.0E-12								Y
				Ce-144	3.0E-11	1.0E-03						3.0E-14								Y
				Pm-147	1.0E-09	1.0E-03						1.0E-12								Y
151	2117	FHE-28	Preparing Calibration Standards	H-3	2.3E-05	1.0E-03	19.2	0.41	7.3	None	1	2.3E-08	1308	E	1.8E-08	1125	NNE	5.0E-08	2	Y
				C-14	2.2E-06	1.0E-03						2.2E-09								Y
				U-235	4.6E-09	1.0E-03						4.6E-12								Y
				U-238	6.2E-09	1.0E-03						6.2E-12								Y
				Pu-239	1.8E-07	1.0E-03						1.8E-10								Y
				Am-241	4.6E-09	1.0E-03						4.6E-12								Y
				Am-243	4.6E-09	1.0E-03						4.6E-12								Y
				Sr-90	1.8E-07	1.0E-03						1.8E-10								Y
				Y-90	1.8E-07	1.0E-03						1.8E-10								Y
				Cs-137	4.6E-09	1.0E-03						4.6E-12								Y
				Co-57	3.7E-09	1.0E-03						3.7E-12								Y
				Co-60	3.7E-09	1.0E-03						3.7E-12								Y
				Mn-54	3.7E-09	1.0E-03						3.7E-12								Y
				Ce-144	3.7E-09	1.0E-03						3.7E-12								Y
151	2121	FHE-29	Preparation of	H-3	1.8E-06	1.0E-03	19.2	0.41	6.9	None	1	1.8E-09	1308	E	2.2E-08	1125	NNE	6.2E-08	2	Y
			Calibration Standards	C-14	1.8E-07	1.0E-03						1.8E-10								Y
				U-235	5.0E-09	1.0E-03						5.0E-12								Y
				U-238	7.2E-09	1.0E-03						7.2E-12								Y
				Pu-239	2.2E-07	1.0E-03						2.2E-10								Y
				Am-241	6.0E-09	1.0E-03						6.0E-12								Y
				Am-243	6.0E-09	1.0E-03						6.0E-12								Y
				Sr-90	3.1E-07	1.0E-03						3.1E-10								Y
				Y-90	3.1E-07	1.0E-03						3.1E-10								Y
				Cs-137	6.0E-09	1.0E-03						6.0E-12								Y
				Co-57	4.3E-09	1.0E-03						4.3E-12								Y
				Co-60	4.3E-09	1.0E-03						4.3E-12								Y
				Mn-54	4.3E-09	1.0E-03						4.3E-12								Y
				Ce-144	1.0E-07	1.0E-03						1.0E-10								Y
151	2125	FHE-46	Aliquiot Extraction	Bi-207	8.0E-06	1.0E-03	19.2	0.41	6.2	None	1	8.0E-09	1308	E	5.4E-11	1125	NNE	1.5E-10	2	Y
				Pu-239	3.0E-10	1.0E-03						3.0E-13								Y
				Pu-244	3.0E-10	1.0E-03						3.0E-13								Y
				H-3	3.0E-10	1.0E-03						3.0E-13								Y
				C-14	1.0E-09	1.0E-03						1.0E-12								Y
151	2131	FHE-56	No Operations	None	None	NA	NA	NA	NA	None	1	0.0E+00	1308	E	0.0E+00	NA	NA	0.0E+00	2	Y
151	2143	FHE-63	No Operations	None	None	NA	NA	NA	NA	None	1	0.0E+00	1308	E	0.0E+00	NA	NA	0.0E+00	2	Y

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category	Below App. E Quantity
151	2149	FHE-78	Tracer Preparation	Pu-238	2.0E-14	1.0E-03	19.2	0.41	6.9	None	1	2.0E-17	1308	E	4.1E-13	1125	NNE	1.2E-12	2	Y
				Pu-239	4.0E-14	1.0E-03						4.0E-17								Y
				Pu-240	4.0E-14	1.0E-03						4.0E-17								Y
				Pu-242	3.0E-12	1.0E-03						3.0E-15								Y
				U-232	1.0E-12	1.0E-03						1.0E-15								Y
				U-233	9.0E-13	1.0E-03						9.0E-16								Y
				U-238	4.0E-15	1.0E-03						4.0E-18								Y
151	2302 and 2302A	FHE-09	Process and Weigh Samples	Ce-144	3.0E-11	1.0E-03	19.2	0.41	7.3	None	1	3.0E-14	1308	E	1.6E-14	1125	NNE	4.5E-14	2	Y
				Pm-147	1.0E-09	1.0E-03						1.0E-12								Y
151	2318	FHE-22	Sample Preparation	C-14	1.2E-09	1.0E-03	19.2	0.41	6.2	None	1	1.2E-12	1308	E	1.5E-14	1125	NNE	4.3E-14	2	Y
Building 166 is part of LLNL's Uranium Atomic Vapor Laser Isotope Separation (U-AVLIS) program, now affiliated with The United States Enrichment Corporation (USEC).																				
*Gross alpha and gross beta emissions are continously monitored at the stack. Monitoring data, rather than the inventory approach, are used to determine emissions.																				
**Because monitoring takes place after HEPA filtration, an unabated EDE cannot be determined (see discussion on page 40.)																				
166	HiBay	Stack	Conversion of uranium	Gross alpha	*	N/A	7.9	0.25	3.9	HEPA	0.01	0.0E+00	1291	E	0.0E+00	* *	* *	* *	3	N/A
			to halides and oxides of	Gross beta	*	N/A						0.0E+00								N/A
			uranium			N/A														N/A
Building 175 is part of LLNL's Uranium Atomic Vapor Laser Isotope Separation (U-AVLIS) program, now affiliated with The United States Enrichment Corporation (USEC).																				
*Gross alpha and gross beta emissions are continously monitored at the stack. Monitoring data, rather than the inventory approach, are used to determine emissions.																				
**Because monitoring takes place after HEPA filtration, an unabated EDE cannot be determined (see discussion on page 40.)																				
175		Stack 1	Cleaning & Refurbishment	Gross alpha	*	N/A	13.0	0.71	4.1	HEPA	0.01	0.0E+00	1335	ESE	0.0E+00	* *	* *	* *	3	N/A
		Stack 2	of Parts	Gross beta	*	N/A	13.0	0.71	9.1	HEPA		0.0E+00								N/A
		Stack 3					13.0	0.61	3.9	HEPA										N/A
		Stack 4					13.0	0.61	5.6	HEPA										
		Stack 5					10.0	0.38	1.1	HEPA										
		Stack 6					10.0	0.36	5.1	HEPA										
Building 177 is part of LLNL's Uranium Atomic Vapor Laser Isotope Separation (U-AVLIS) program, now affiliated with The United States Enrichment Corporation (USEC).																				
177	1014	FHE-10	Cleaning Parts and Process	U-238	1.0E-04	1.0E-03	5.8	0.41	2.4	HEPA	0.01	1.0E-09	1350	ESE	1.3E-07	764	NNE	1.5E-04	2	Y
			Uranium Oxide Powders	U-235	2.2E-05	1.0E-03						2.2E-10								Y
				U-234	4.0E-04	1.0E-03						4.0E-09								Y
177	1015	FHE-27	Sample Preparation	U-238	2.5E-05	1.0E-06	7.9	0.56	12.9	HEPA	0.01	2.5E-13	1350	ESE	3.0E-12	764	NNE	8.1E-09	2	Y
				U-235	7.0E-07	1.0E-06						7.0E-15								Y
				U-234	1.7E-05	1.0E-06						1.7E-13								Y
177	1020	FHE-22	Cleaning & Refurbishment	U-238	3.3E-02	1.0E-03	6.4	0.30	8.9	HEPA	0.01	3.3E-07	1350	ESE	6.5E-06	764	NNE	1.1E-02	2	N
			of Parts	U-235	4.0E-04	1.0E-03						4.0E-09								Y
				U-234	1.4E-02	1.0E-03						1.4E-07								N
177	1021	FHE-24/25	Sample Preparation	U-238	1.3E-04	1.0E-03	11.0	0.41	7.8	HEPA	0.01	1.3E-09	1350	ESE	8.2E-08	764	NNE	2.0E-04	2	Y
				U-235	4.3E-05	1.0E-03						4.3E-10								Y
				U-234	8.0E-04	1.0E-03						8.0E-09								Y
Building 179 is part of LLNL's Uranium Atomic Vapor Laser Isotope Separation (U-AVLIS) program, now affiliated with The United States Enrichment Corporation (USEC).																				
179	1000	179-1000-RA1	No Operations	None	None	NA	NA	NA	NA	None	1	0.0E+00	1296	ESE	0.0E+00	NA	NA	0.0E+00	2	Y
179	1020	179-1020-RA1	No Operations	None	None	NA	NA	NA	NA	None	1	0.0E+00	1296	ESE	0.0E+00	NA	NA	0.0E+00	2	Y
Building 194 is operated by N-Division for the Physics and Space Technology Directorate Center for Accelerator and Mass Spectroscopy (CAMS) and E-Division.																				
The complex houses a high energy linear accelerator and research laboratories. The accelerator beam can produce small quantities of short-lived air activation products.																				
194	Target	TE-FE4	Positron Beam Generation	O-15	2.3E+00	1.0E+00	30.5	1.37	4.5	None	1	2.3E+00	1524	ESE	2.5E-05	538	NE	2.4E-03	2	N/A
	Exhaust			N-13	4.4E+00	1.0E+00						4.4E+00								N/A
194	1131	1131-RA	Positron Lifetime Experiments	Na-22	2.0E-03	1.0E-06	8.5	0.50	0.5	None	1	2.0E-09	1524	ESE	1.0E-09	412	NNE	3.1E-08	2	Y
194	B124A	TE-FE4	No Operations	None	None	NA	30.5	1.37	4.5	None	1	0.0E+00	1524	ESE	0.0E+00	NA	NA	0.0E+00	2	Y
Building 212 is administered by the Physics and Space Technology Directorate (formerly the Physical Sciences Directorate) for miscellaneous physics experiments.																				
The current radionuclide emissions are due to contamination from past operations of the rotating target neutron source, which is no longer in operation.																				
212	174	FHE-7	Contamination	H-3	1.1E-02	1.0E-06	4.3	0.50	0.5	None	1	1.1E-08	1278	ENE	8.0E-12	38	SW	4.1E-10	2	Y
212	184	212-184-RA	Contamination	H-3	1.1E-02	1.0E-06	4.3	0.50	0.5	None	1	1.1E-08	1278	ENE	8.0E-12	38	SW	4.1E-10	2	Y
Building 222 is part of the Chemistry and Material Sciences Directorate. Many of the laboratories either store or used depleted uranium.																				
The depleted uranium usually exists as a solid, either as metal pieces or in chemical reagents such as oxide powders. The other source of radionuclides in Building 222 is from analysis of hazardous-waste samples.																				
***In some instances, emissions from stacks or room air sources have been combined, as permitted by the EPA/DOE Memorandum of Understanding.																				
222	1020B	FHE-4000	Gas Transfer	H-3	1.0E-02	1.0E+00	28.0	0.41	17.8	None	1	1.0E-02	1239	ENE	2.9E-06	253	SW	5.1E-06	2	Y
222	1028B	FHE-3000	No Operations	None	None	NA	12.8	1.07	15.6	HEPA	0.01	0.0E+00	1239	ENE	0.0E+00	NA	NA	0.0E+00	2	Y
222	1106	FHE-55	Cleaning of Equipment	Th-232	2.1E-08	1.0E-06	5.5	0.41	3.1	HEPA	0.01	2.1E-16	1239	ENE	1.0E-13	253	SW	9.4E-11	2	Y
				U-238	6.4E-08	1.0E-06						6.4E-16								Y
222	1110B	FHE-6	No Operations	None	None	NA	9.8	0.46	5.2	HEPA	0.01	0.0E+00	1239	ENE	0.0E+00	NA	NA	0.0E+00	2	Y
222	1161	FHE-128	Chemical Analysis	Ni-63	1.4E-02	1.0E-06	6.1	0.20	10.2	None	1	1.4E-08	1239	ENE	2.1E-07	253	SW	1.9E-06	2	Y
				Gross Alpha	1.0E-06	1.0E-03						1.0E-09								Y
				Gross Beta	1.0E-06	1.0E-03						1.0E-09								Y

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category	Below App. E Quantity
222	1169	FHE-1000	Chemical Analysis	Gross Alpha	1.0E-08	1.0E-03	10.7	0.97	19.4	None	1	1.0E-11	1239	ENE	1.4E-09	253	SW	4.4E-09	2	Y
				Gross Beta	1.0E-08	1.0E-03						1.0E-11								Y
222	1216B	FHE-1000	Chemical Analysis	Gross Alpha	1.0E-06	1.0E-03	10.7	0.97	19.4	None	1	1.0E-09	1239	ENE	1.4E-07	253	SW	4.4E-07	2	Y
				Gross Beta	1.0E-06	1.0E-03						1.0E-09								Y
				Ni-63	7.5E-02	1.0E-06						7.5E-08								Y
222	1223A/B	FHE-1000	No Operations	None	None	NA	10.7	0.97	19.4	HEPA	0.01	0.0E+00	1239	ENE	0.0E+00	NA	NA	0.0E+00	2	Y
222	1228B	FHE-1000	Chemical analysis of waste	Gross Alpha	2.5E-06	1.0E-03	10.7	0.97	19.4	None	1	2.5E-09	1239	ENE	3.4E-07	253	SW	1.1E-06	2	Y
				Gross Beta	2.5E-06	1.0E-03						2.5E-09								Y
222	1318B***	FHE-1000/HDCH-21	Analysis of waste samples	H-3	4.5E-07	1.0E-03	10.7	0.97	19.4	None	1	4.5E-10	1239	ENE	5.2E-08	191	SSW	2.1E-07	1	Y
	1510C***	FHE-67	Sample preparation	Gross Alpha	3.6E-07	1.0E-03	5.0	0.26	8.3	None	1	3.6E-10								Y
				Gross Beta	3.6E-07	1.0E-03						3.6E-10								Y
				Gamma	3.6E-07	1.0E-03						3.6E-10								Y
222	1405	Room Air	Chemical analysis	Gross Alpha	4.0E-07	1.0E-03	NA	NA	NA	None	1	4.0E-10	1239	ENE	1.1E-07	253	SW	3.1E-06	2	Y
				Gross Beta	4.0E-07	1.0E-03						4.0E-10								Y
222	1421	FHE-2000	Chemical analysis	U-234	1.3E-14	1.0E-03	10.7	0.84	13.7	None	1	1.3E-17	1239	ENE	1.4E-15	253	SW	5.5E-15	2	Y
				U-235	1.4E-15	1.0E-03						1.4E-18								Y
				U-238	1.2E-14	1.0E-03						1.2E-17								Y
222	1428	FHE-2000	Chemical analysis	Ni-63	2.9E-02	1.0E+00	10.7	0.84	13.7	None	1	2.9E-02	1239	ENE	1.6E-04	253	SW	6.5E-04	2	Y
222	1506	FHE-108	Gas chromatography	H-3	3.1E-01	1.0E+00	5.0	0.25	9.3	None	1	3.1E-01	1239	ENE	1.7E-04	253	SW	1.6E-03	2	Y
222	1507***	Room Air	Analysis of gravel samples	H-3	1.1E-06	1.0E+00	NA	NA	NA	None	1	1.1E-06	1239	ENE	6.9E-10	253	SW	7.3E-09	1	Y
	1510A***	Room Air	Analysis of samples	Gross Alpha	9.0E-12	1.0E-03	NA	NA	NA	None	1	9.0E-15								Y
	1526B***	Room Air	Uranium oxide dissolution studies	Gross Beta	9.0E-12	1.0E-03	NA	NA	NA	None	1	9.0E-15								Y
				Gamma	9.0E-12	1.0E-03						9.0E-15								Y
				U-238	1.8E-11	1.0E-03						1.8E-14								Y
				U-238	5.6E-11	1.0E-06						5.6E-17								Y
222	1511B	FHE-114	Chemical analysis	U-234	2.6E-12	1.0E-03	6.1	0.36	4.8	None	1	2.6E-15	1239	ENE	3.9E-13	253	SW	3.6E-12	2	Y
				U-235	1.1E-13	1.0E-03						1.1E-16								Y
				U-238	2.4E-12	1.0E-03						2.4E-15								Y
222	1515B	FHE-73	Chemical analysis	Gross Alpha	2.0E-06	1.0E-03	5.0	0.25	9.3	None	1	2.0E-09	1239	ENE	4.4E-07	253	SW	4.2E-06	2	Y
				Gross Beta	2.0E-06	1.0E-03						2.0E-09								Y
222	1520	FHE-116	Optical emission spectroscopy	U-234	3.2E-09	1.0E-06	4.4	0.33	7.4	None	1	3.2E-15	1239	ENE	5.0E-13	253	SW	4.9E-12	2	Y
				U-235	1.4E-10	1.0E-06						1.4E-16								Y
				U-238	3.0E-09	1.0E-06						3.0E-15								Y
222	1520B	FHE-75	Sample preparation	U-234	3.2E-09	1.0E-06	4.9	0.33	6.5	None	1	3.2E-15	1239	ENE	5.0E-13	253	SW	4.9E-12	2	Y
				U-235	1.4E-10	1.0E-06						1.4E-16								Y
				U-238	3.0E-09	1.0E-06						3.0E-15								Y
222	1520C	Room Air	Gravimetric	U-234	3.2E-09	1.0E-06	NA	NA	NA	None	1	3.2E-15	1239	ENE	6.1E-13	253	SW	1.7E-11	2	Y
				U-235	1.4E-10	1.0E-06						1.4E-16								Y
				U-238	3.0E-09	1.0E-06						3.0E-15								Y
222	1523C	FHE-94	Chemical extraction	Gross Alpha	1.2E-06	1.0E-03	6.1	0.23	11.5	None	1	1.2E-09	1239	ENE	2.4E-07	253	SW	2.2E-06	2	Y
				Gross Beta	1.2E-06	1.0E-03						1.2E-09								Y

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category	Below App. E Quantity
Building 224 is operated by the Chemistry and Materials Science Directorate. The facility houses laboratories that perform digestion and analysis of waste samples.																				
224	110	FHE-1000	Sample digestion/	Gross Alpha	2.5E-04	1.0E-03	7.6	0.31	11.0	None	1	2.5E-07	1170	ENE	4.8E-05	255	SW	3.5E-04	2	Y
			chemical analysis	Gross Beta	2.5E-04	1.0E-03						2.5E-07								Y
224	114	FHE-5	Waste collection	Gross Alpha	5.0E-05	1.0E-03	5.6	0.41	3.6	None	1	5.0E-08	1170	ENE	1.3E-05	255	SW	1.1E-04	2	Y
				Gross Beta	5.0E-05	1.0E-03						5.0E-08								Y
224	115	FHE-4	Chemical analysis	Gross Alpha	5.0E-08	1.0E-03	6.7	0.33	6.6	None	1	5.0E-11	1170	ENE	1.1E-08	255	SW	8.9E-08	2	Y
				Gross Beta	5.0E-08	1.0E-03						5.0E-11								Y
224	117	FHE-1	Chemical analysis	Gross Alpha	1.0E-07	1.0E-03	5.9	0.25	9.3	None	1	1.0E-10	1170	ENE	2.2E-08	255	SW	1.9E-07	2	Y
				Gross Beta	1.0E-07	1.0E-03						1.0E-10								Y
Building 226 is operated by the Chemistry and Materials Science Directorate. The facility houses chemistry laboratories that prepare and analyze various media such as soil, vegetation, and waste samples for toxic chemical and radioactivity analysis.																				
Radioactive material can exist in this facility, either in the samples or in the prepared standards.																				
226	106	FE-4	Scintillation counting	Gross Alpha	2.5E-11	1.0E-03	6.4	0.10	11.1	None	1	2.5E-14	1155	ENE	6.3E-12	298	SW	4.3E-11	2	Y
				Gross Beta	2.5E-11	1.0E-03						2.5E-14								Y
226	109	FHE-2	Sample preparation	Gross Alpha	2.5E-09	1.0E-03	5.9	0.28	7.5	None	1	2.5E-12	1155	ENE	5.8E-10	298	SW	4.1E-09	2	Y
				Gross Beta	2.5E-09	1.0E-03						2.5E-12								Y
Building 227 is part of the Chemistry and Material Science Directorate. In room 1083, liquid samples containing very small amounts																				
of depleted uranium are studied to determine the leaching properties of natural waters.																				
227	1026	HDCH-9/FHE-1000	Analysis of waste samples	U-238	5.0E-15	1.0E-03	13.7	1.12	12.8	None	1	5.0E-18	1155	ENE	2.6E-16	262	SSW	7.5E-16	1	Y
227	1036	Room Air	No Operations	None	None	NA	NA	NA	NA	None	1	0.0E+00	1155	ENE	0.0E+00	344	SW	0.0E+00	2	Y
227	1044	Room Air	No Operations	None	None	NA	NA	NA	NA	None	1	0.0E+00	1155	ENE	0.0E+00	344	SW	0.0E+00	2	Y
227	1083	Room Air	Leaching studies	U-234	1.1E-06	1.0E-03	NA	NA	NA	None	1	1.1E-09	1155	ENE	2.4E-07	344	SW	3.9E-06	2	Y
				U-235	4.7E-08	1.0E-03						4.7E-11								Y
				U-238	1.0E-06	1.0E-03						1.0E-09								Y
227	1084	Room Air	Leaching studies	U-234	3.2E-08	1.0E-03	NA	NA	NA	None	1	3.2E-11	1155	ENE	7.0E-09	344	SW	1.1E-07	2	Y
				U-235	1.4E-09	1.0E-03						1.4E-12								Y
				U-238	3.0E-08	1.0E-03						3.0E-11								Y
The 231 complex houses research and development activities conducted by the Chemistry and Materials Science Directorate, Engineering, Weapons Engineering, and Safeguards and Security Materials Management Division.																				
Management oversight for Building 231 is provided by the Engineering Directorate through the Engineering Sciences Division.																				
*Gross alpha and gross beta emissions are continously monitored at the stack. Monitoring data, rather than the inventory approach, are used to determined emissions.																				
**Because monitoring takes place after HEPA filtration, an unabated EDE cannot be determined (see discussion on page 40.)																				
231	1128	FHE-31-1,2	Storage of Radionuclides	Gross Alpha	*	NA	12.2	0.41	12.0	HEPA	0.01	0.0E+00	1167	E	0.0E+00	* *	* *	* *	3	N/A
231	1330	FHE-63/64	Repackaging	U-234	9.3E-01	1.0E-06	10.6	0.56	6.0	HEPA	0.01	9.3E-09	1167	ENE	6.7E-06	568	SW	1.8E-03	2	Y
				U-235	1.3E-01	1.0E-06						1.3E-09								Y
				U-238	1.0E+01	1.0E-06						1.0E-07								N
231	1351	FHE-63/64	Verification of packaging	U-234	9.3E+00	1.0E-06	10.6	0.56	6.0	HEPA	0.01	9.3E-08	1167	ENE	6.7E-05	568	SW	1.8E-02	2	N
				U-235	1.3E+00	1.0E-06						1.3E-08								Y
				U-238	1.0E+02	1.0E-06						1.0E-06								N
231	1600	Room Air	Tensile testing	U-234	1.4E-06	1.0E-06	NA	NA	NA	None	1	1.4E-12	1167	E	2.5E-10	568	SW	1.7E-09	1	Y
				U-235	2.0E-08	1.0E-06						2.0E-14				and				Y
				U-238	1.5E-06	1.0E-06						1.5E-12				671	W	1.7E-09		Y
231	1737	FHE-54	Electron beam welding	Th-232	3.2E-06	1.0E-06	10.5	0.46	2.0	HEPA	0.01	3.2E-14	1167	ENE	6.1E-12	568	SW	1.8E-09	2	Y
231	1737A	FHE-54	No Operations	None	None	NA	10.5	0.46	2.0	None	1	0.0E+00	1167	ENE	0.0E+00	NA	NA	0.0E+00	2	Y
231	1900HB	FGB-7/8	Storage	U-234	1.9E-10	1.0E-06	2.4	0.20	14.4	None	1	1.9E-16	1167	ENE	2.0E-13	568	SW	5.5E-13	2	Y
				U-235	2.6E-11	1.0E-06						2.6E-17								Y
				U-238	2.0E-09	1.0E-06						2.0E-15								Y
231	1944	FHE-42	Heat treatment studies	U-234	1.9E-10	1.0E-06	2.4	0.36	40.4	HEPA	0.01	1.9E-18	1167	ENE	1.3E-15	568	SW	2.9E-13	2	Y
				U-235	2.6E-11	1.0E-06						2.6E-19								Y
				U-238	2.0E-09	1.0E-06						2.0E-17								Y
231	1945	FHE-40	Sample preparation	U-234	1.9E-10	1.0E-06	10.7	0.36	3.8	None	1	1.9E-16	1167	ENE	1.4E-13	568	SW	4.1E-13	2	Y
				U-235	2.6E-11	1.0E-06						2.6E-17								Y
				U-238	2.0E-09	1.0E-06						2.0E-15								Y
231	1945A	Room Air	Scanning electron microscopy	U-234	1.9E-13	1.0E-06	NA	NA	NA	None	1	1.9E-19	1167	ENE	2.3E-16	439	SSW	1.7E-15	2	Y
				U-235	2.6E-14	1.0E-06						2.6E-20								Y
				U-238	2.0E-12	1.0E-06						2.0E-18								Y
231	1945B	FHE-40	Metallography sample	U-234	6.8E-03	1.0E-03	10.7	0.36	3.8	None	1	6.8E-06	1167	ENE	1.3E-03	568	SW	3.7E-03	2	Y
			preparation	U-235	3.5E-04	1.0E-03						3.5E-07								Y
				U-238	1.2E-02	1.0E-03						1.2E-05								N
231	1945C	Room Air	Microscopy	U-234	1.9E-13	1.0E-06	NA	NA	NA	None	1	1.9E-19	1167	ENE	2.3E-16	439	SSW	1.7E-15	2	Y
				U-235	2.6E-14	1.0E-06						2.6E-20								Y
				U-238	2.0E-12	1.0E-06						2.0E-18								Y
231	1945D	Room Air	Metallographic analysis	U-234	1.9E-10	1.0E-06	NA	NA	NA	None	1	1.9E-16	1167	ENE	2.3E-13	439	SSW	1.7E-12	2	Y
				U-235	2.6E-11	1.0E-06						2.6E-17								Y
				U-238	2.0E-09	1.0E-06						2.0E-15								Y

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category	Below App. E Quantity
231	1945E	Room Air	Wet grinding/polishing	U-234	1.9E-07	1.0E-03	NA	NA	NA	None	1	1.9E-10	1167	ENE	2.3E-07	439	SSW	1.7E-06	2	Y
				U-235	2.6E-08	1.0E-03						2.6E-11								Y
				U-238	2.0E-06	1.0E-03						2.0E-09								Y
231	1956A	FGBE-7/8	Metal casting	U-234	9.2E-06	1.0E-06	2.4	0.20	14.3	None	1	9.2E-12	1167	ENE	9.8E-09	568	SW	2.7E-08	2	Y
				U-235	1.3E-06	1.0E-06						1.3E-12								Y
				U-238	9.9E-05	1.0E-06						9.9E-11								Y
231	1956A	FHE-43	Metal casting	U-234	9.2E-06	1.0E-06	8.8	0.50	7.2	HEPA	0.01	9.2E-14	1167	ENE	6.8E-11	568	SW	1.9E-08	2	Y
				U-235	1.3E-06	1.0E-06						1.3E-14								Y
				U-238	9.9E-05	1.0E-06						9.9E-13								Y
231	2934	FHE-23	Lapping/cutting/etching	U-234	3.7E-07	1.0E-03	12.6	0.35	1.7	None	1	3.7E-10	1167	ENE	2.8E-07	568	SW	7.8E-07	2	Y
				U-235	5.1E-08	1.0E-03						5.1E-11								Y
				U-238	4.0E-06	1.0E-03						4.0E-09								Y
Building 235 is part of the Chemistry and Materials Sciences Directorate. Operations in the facility include examination of material structure, surface, and subsurface; precision cutting, ion implanting, and metallurgical studies.																				
Most of the depleted uranium in this building is there for characterization studies; some is used for ion beam implantation experiments. Chemical characterization studies take place in rooms 1100, 1224, and 1226.																				
Up to 500 grams each of depleted uranium and thorium might be present in each of these rooms.																				
235	1100	FHE-2001	No Operations	None	None	NA	11.1	2.30	0.2	HEPA	0.01	0.0E+00	1065	ENE	0.0E+00	NA	NA	0.0E+00	2	Y
235	1121	Room Air	Scanning electron microscopy	U-234	1.1E-08	1.0E-06	NA	NA	NA	None	1	1.1E-14	1065	ENE	2.7E-12	556	SW	1.7E-11	2	Y
				U-235	4.7E-10	1.0E-06						4.7E-16								Y
				U-238	1.0E-08	1.0E-06						1.0E-14								Y
235	1123	Room Air	No Operations	None	None	NA	NA	NA	NA	None	1	0.0E+00	1065	ENE	0.0E+00	NA	NA	0.0E+00	2	Y
235	1125	Room Air	Scanning electron microscopy	U-234	6.4E-10	1.0E-06	NA	NA	NA	None	1	6.4E-16	1065	ENE	1.6E-13	556	SW	1.0E-12	2	Y
				U-235	2.8E-11	1.0E-06						2.8E-17								Y
				U-238	6.0E-10	1.0E-06						6.0E-16								Y
235	1131	FHE-2	Metallographic sample preparation	U-234	1.8E-04	1.0E-06	8.2	0.31	12.3	None	1	1.8E-10	1065	ENE	2.7E-08	556	SW	7.0E-08	2	Y
				U-235	7.9E-06	1.0E-06						7.9E-12								Y
				U-238	1.7E-04	1.0E-06						1.7E-10								Y
235	1133	Room Air	Microstructure examination	U-234	5.3E-06	1.0E-06	NA	NA	NA	None	1	5.3E-12	1065	ENE	1.3E-09	556	SW	8.5E-09	2	Y
				U-235	2.3E-07	1.0E-06						2.3E-13								Y
				U-238	5.0E-06	1.0E-06						5.0E-12								Y
235	1138	FHE-1001/HD-13	Sample preparation	U-234	1.1E-08	1.0E-06	9.8	2.30	2.4	HEPA	0.01	1.1E-16	1065	ENE	1.5E-14	556	SW	3.5E-12	2	Y
				U-235	4.7E-10	1.0E-06						4.7E-18								Y
				U-238	1.0E-08	1.0E-06						1.0E-16								Y
235	1224	FHE-1001/HD-21	Sputter coating	U-234	1.7E-05	1.0E-06	9.8	2.30	2.4	HEPA	0.01	1.7E-13	1065	ENE	1.4E-10	556	SW	3.1E-08	2	Y
				U-235	2.4E-06	1.0E-06						2.4E-14								Y
				U-238	1.9E-04	1.0E-06						1.9E-12								Y
235	1226	FHE-1001/HD-22	Target cleaning	U-234	1.7E-05	1.0E-06	9.8	2.30	2.4	HEPA	0.01	1.7E-13	1065	ENE	1.4E-10	556	SW	3.1E-08	2	Y
				U-235	2.4E-06	1.0E-06						2.4E-14								Y
				U-238	1.9E-04	1.0E-06						1.9E-12								Y
235	1251	FHE-2001	No Operations	None	None	NA	11.1	2.30	0.2	HEPA	0.01	0.0E+00	1065	ENE	0.0E+00	NA	NA	0.0E+00	2	Y

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category	Below App. E Quantity
Building 241 is administered by the Chemistry and Material Sciences Directorate for material properties research and testing. Radionuclide emissions result from contamination from past operations that have been discontinued.																				
241	1600	FGBE-45	Oxidation of uranium	U-238	1.0E-08	1.0E-06	12.5	0.30	5.6	HEPA	0.01	1.0E-16	1140	E	4.2E-15	821	SW	1.0E-12	2	Y
241	1629	Room Air	X-ray diffraction analysis	U-238	6.0E-11	1.0E-03	NA	NA	NA	None	1	6.0E-14	1140	E	4.2E-12	697	W	3.6E-11	2	Y
241	1822	Room Air	X-ray diffraction analysis	U-238	2.0E-08	1.0E-06	NA	NA	NA	None	1	2.0E-14	1140	E	1.4E-12	697	W	1.2E-11	2	Y
241	1838	FGBE-9 &10	Ceramic waste form research	U-238	8.0E-08	1.0E-03	12.2	0.46	1.6	HEPA	0.01	8.0E-13	1140	E	3.7E-11	661	SSW	9.2E-09	1	Y
241	1841	FHE-53	Reaction of uranium oxide with chlorine	U-238	7.5E-07	1.0E-03	7.0	0.25	11.2	HEPA	0.01	7.5E-12	1140	E	3.5E-10	821	SW	8.7E-08	2	Y
241	1887	FGBE-27	No Operations	None	None	NA	11.3	0.23	21.7	HEPA	0.01	0.0E+00	1140	E	0.0E+00	NA	NA	0.0E+00	2	Y
241	1896	FHE-27	UV spectroscopy	U-238	3.0E-11	1.0E-03	7.0	0.25	14.9	None	1	3.0E-14	1140	E	1.3E-12	821	SW	3.4E-12	2	Y
Building 251, the Heavy Element Facility, is operated by the Defense and Nuclear Technologies Directorate as a facility for handling radioactive materials, especially transuranic isotopes.																				
One area of the facility has been "hardened" to resist damage from earthquakes. Room exhausts from this hardened area are double HEPA filtered; glove box exhausts are triple HEPA filtered.																				
Exhausts from the hardened area are continuously monitored by alpha alarm detectors (CAMs). Exhausts from the unhardened area, also HEPA filtered, are continously sampled by simple filter systems.																				
*Air exhausts of the Building 251 hardened area are required to have continuous monitoring; measured emissions, rather than the inventory approach, are used to determine annual emissions.																				
**Because monitoring takes place after HEPA filtration, an unabated EDE cannot be determined (see discussion on page 40.)																				
***Stack emissions have been combined as permitted by the EPA/DOE Memorandum of Understanding.																				
251	Unhardened Area	FGBE-15,16	General Chemistry	Gross Alpha	*	NA	5.5	0.10	8.0	Double HEPA	0.0001	7.5E-08	1188	E	1.5E-05	* *	* *	* *	3	N/A
	Fume glove box exhaust			Gross Beta								8.1E-07								
251	Unhardened Area	FHE-5	General Chemistry	Gross Alpha	*	NA	4.3	0.26	8.6	Double HEPA	0.0001	0.0E+00	1188	E	0.0E+00	* *	* *	* *	3	N/A
	Fume hood and	FHE-4		Gross Beta			4.3	0.27	4.2			0.0E+00								
	glove box	FHE-6					6.4	0.25	8.0											
	exhaust***	FHE-7					6.4	0.25	4.3											
		FGBE-27,28					5.5	0.76	0.6											
		FHE-10					4.3	0.28	13.7											
		FFE-12					4.3	0.25	7.6											
		FGBE-29,30					5.5	0.13	7.1											
		FFE-14					4.3	0.34	1.0											
		FGBE-31,32					5.5	0.87	0.1											
		FGBE-33,34					8.0	0.15	12.8											
		FHE-13					4.3	0.31	4.0											
		FGBE-42,43					5.5	0.36	12.7											
		FGBE-40,41					5.5	0.23	5.6											
		FGBE-44,45					10.2	0.15	10.2											
		FFE-19					4.3	0.29	8.6											
		FFE-15					4.3	0.31	7.6											
		FHE-9					4.3	0.26	5.1											
		FHE-10					4.3	0.24	4.6											
		FFE-6					4.3	0.31	7.6											
		FGBE-25,26					8.5	0.10	12.8											
		FGBE-21,22					5.5	0.11	7.6											
		FFE-7					5.5	0.33	1.1											
		FHE-8					4.3	0.32	4.1											
		FHE-38,39					7.2	0.15	5.1											
		FFE-9					4.3	0.19	14.7											
		FHE-16					4.3	0.36	5.6											
		FFE-24					4.3	0.45	2.7											
		FHE-14					4.3	0.31	9.1											
		FHE-15					4.3	0.31	9.1											
		FHE-13					4.3	0.40	6.2											
		FFE-21					4.3	0.24	6.1											
		FFE-22					4.3	1.40	1.0											
		FFE-23					4.3	0.34	9.1											
		FGBE-35,36					4.3	0.13	11.2											
		FHE-12					4.3	0.32	9.1											
251	Hardened Area	FGBE-1000	Transuranic Research	Gross alpha	*	NA	7.8	0.30	4.8	Triple HEPA	0.000001	0.0E+00	1188	E	0.0E+00	* *	* *	* *	3	N/A
	Room Exhaust &	FGBE-2000		Gross beta			7.8	0.30	4.8			0.0E+00								
	Glove Boxes***	FFE-1000					7.8	0.50	11.7											
		FFE-2000					7.8	0.50	11.7											

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category	Below App. E Quantity
Building 253 houses the Hazards Control Department, and the facility includes laboratories for the chemical analysis and counting of radioactive samples.																				
253	1722A	FHE-24	Liquid scintillation counting	H-3	2.5E-11	1.0E-03	7.6	0.36	5.9	None	1	2.5E-14	1116	E	3.7E-17	1079	NNE	1.0E-16	2	Y
253	1732	FHE-23	HNO3 digestion of samples above 100 deg. C.	Gross Alpha	1.3E-13	1.0E-03	6.1	0.36	7.1	None	1	1.3E-16	1116	E	3.8E-14	800	WSW	8.8E-14	1	Y
				Gross Beta	2.1E-13	1.0E-03						2.1E-16								Y
				Th-230	1.5E-13	1.0E-03						1.5E-16								Y
				Cs-137	9.0E-14	1.0E-03						9.0E-17								Y
253	1734	Room Air	Distillation of spikes and sewer samples	H-3	9.9E-10	1.0E-03	NA	NA	NA	None	1	9.9E-13	1116	E	6.3E-13	736	W	4.7E-12	2	Y
				Pu-239	2.8E-12	1.0E-03						2.8E-15								Y
				Sr-90	1.2E-11	1.0E-03						1.2E-14								Y
253	1734A	FGBE-142	Sieve soil samples	Pu-239	2.7E-10	1.0E-06	6.1	0.10	23.6	HEPA	0.01	2.7E-18	1116	E	4.2E-16	1079	NNE	1.1E-13	2	Y
				Sr-90	4.6E-10	1.0E-06						4.6E-18								Y
253	1734B	FHE-2	Samples and standards plated and flamed	Cs-137	1.7E-11	1.0E-03	6.4	0.30	8.7	None	1	1.7E-14	1116	E	2.1E-12	1079	NNE	5.5E-12	2	Y
				Th-230	2.2E-12	1.0E-03						2.2E-15								Y
				Pu-239	1.2E-11	1.0E-03						1.2E-14								Y
				Sr-90	1.7E-12	1.0E-03						1.7E-15								Y
				Y-90	7.8E-13	1.0E-03						7.8E-16								Y
				Np-237	6.4E-13	1.0E-03						6.4E-16								Y
				H-3	4.3E-12	1.0E-03						4.3E-15								Y
253	1734C	FHE-4	Quality control sample aliquoting	H-3	2.2E-14	1.0E-03	6.4	0.30	7.2	None	1	2.2E-17	1116	E	1.9E-12	1079	NNE	5.0E-12	2	Y
				Np-237	3.0E-12	1.0E-03						3.0E-15								Y
				Sr-90	2.5E-12	1.0E-03						2.5E-15								Y
				Y-90	2.5E-12	1.0E-03						2.5E-15								Y
				Cs-137	3.7E-12	1.0E-03						3.7E-15								Y
				Th-230	4.8E-13	1.0E-03						4.8E-16								Y
				Pu-239	7.5E-12	1.0E-03						7.5E-15								Y
253	1734D	FHE-11	Acid digestion for gross alpha/beta	H-3	6.8E-09	1.0E-03	10.4	0.30	12.3	None	1	6.8E-12	1116	E	7.7E-12	1079	NNE	2.0E-11	2	Y
				Pu-239	5.3E-11	1.0E-03						5.3E-14								Y
				Sr-90	2.6E-10	1.0E-03						2.6E-13								Y
				Y-90	2.6E-12	1.0E-03						2.6E-15								Y
				Np-237	3.1E-12	1.0E-03						3.1E-15								Y
253	1906	Room Air	Sample preparation for liquid scintillation counting	H-3	9.0E-09	1.0E-03	NA	NA	NA	None	1	9.0E-12	1116	E	4.9E-15	736	W	2.8E-14	1	Y
253	1907	FHE-10	Analysis of urine for radionuclides	H-3	1.2E-10	1.0E-03	2.1	0.37	5.5	None	1	1.2E-13	1116	E	6.5E-17	800	WSW	2.5E-16	1	Y
				U-234	8.3E-17	1.0E-03						8.3E-20								Y
				U-235	3.7E-18	1.0E-03						3.7E-21								Y
				U-238	7.8E-17	1.0E-03						7.8E-20								Y
253	1913	Room Air	Analysis of radon daughter samples	Po-218	7.8E-07	1.0E-03	NA	NA	NA	None	1	7.8E-10	1116	E	5.5E-10	736	W	4.0E-09	2	N/A
				Pb-214	7.8E-07	1.0E-03						7.8E-10								Y
				Bi-214	7.8E-07	1.0E-03						7.8E-10								Y
				Ra-226	4.6E-08	1.0E-06						4.6E-14								Y
253	1914	FEY-1	Aerosol attachment to radon daughter products	Ra-226	3.5E-06	1.0E-03	9.5	0.21	13.7	4 stage HEPA	0.00000001	3.5E-17	1116	E	2.6E-16	1079	NNE	6.6E-08	2	Y
253	1914A	BLV-1	Aerosol attachment to radon daughter products	Po-218	7.8E-05	1.0E+00	5.4	0.05	3.5	HEPA	0.01	7.8E-07	1116	E	7.3E-10	736	W	2.6E-07	2	N/A
				Pb-214	7.8E-05	1.0E+00						7.8E-07				800	WSW	2.6E-07		Y
				Bi-214	7.8E-05	1.0E+00						7.8E-07								Y
Building 254 is run by Hazards Control for the purpose of conducting bioassays and providing analytical services.																				
254	105	Room Air	Analysis of urine for radionuclides	U-238	5.5E-17	1.0E-03	NA	NA	NA	None	1	5.5E-20	1032	E	1.1E-17	817	W	4.5E-17	2	Y
				U-235	2.6E-18	1.0E-03						2.6E-21								Y
				U-234	5.9E-17	1.0E-03						5.9E-20								Y
254	109	FHE-5	Analysis of urine for radionuclides	U-238	1.3E-16	1.0E-03	6.9	0.36	8.3	None	1	1.3E-19	1032	E	1.6E-17	1070	NNE	3.7E-17	2	Y
				U-235	5.9E-18	1.0E-03						5.9E-21								Y
				U-234	1.4E-16	1.0E-03						1.4E-19								Y
254	113	FHE-2	Analysis of urine for radionuclides	Am-243	1.1E-13	1.0E-03	6.9	0.36	6.3	None	1	1.1E-16	1032	E	2.8E-13	1070	NNE	6.9E-13	2	Y
				Pu-242	1.4E-12	1.0E-03						1.4E-15								Y
				Pu-239	2.3E-13	1.0E-03						2.3E-16								Y
254	113A	FHE-3	Analysis of urine for radionuclides	Am-241	8.6E-14	1.0E-03	6.9	0.30	5.1	None	1	8.6E-17	1032	E	5.6E-12	1070	NNE	1.4E-11	2	Y
				Am-243	2.4E-12	1.0E-03						2.4E-15								Y
				Cm-244	9.1E-13	1.0E-03						9.1E-16								Y
				Np-237	9.5E-12	1.0E-03						9.5E-15								Y
				Th-230	9.4E-12	1.0E-03						9.4E-15								Y
				Cf-252	8.4E-12	1.0E-03						8.4E-15								Y
				U-233	2.8E-14	1.0E-03						2.8E-17								Y
				U-234	1.1E-12	1.0E-03						1.1E-15								Y
				U-235	2.8E-14	1.0E-03						2.8E-17								Y
				U-236	8.8E-12	1.0E-03						8.8E-15								Y
				U-238	6.6E-16	1.0E-03						6.6E-19								Y
254	113B	FHE-4	Analysis of urine for radionuclides	P-32	5.6E-12	1.0E-03	6.9	0.30	6.3	None	1	5.6E-15	1032	E	9.7E-13	1070	NNE	2.1E-12	2	Y
				S-35	1.1E-10	1.0E-03						1.1E-13								Y
				C-14	3.5E-11	1.0E-03						3.5E-14								Y
				P-33	1.1E-09	1.0E-03						1.1E-12								Y

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category	Below App. E Quantity
				I-125	1.7E-10	1.0E-03						1.7E-13								Y
				H-3	1.2E-10	1.0E-03						1.2E-13								Y
				Sr-90	2.7E-10	1.0E-03						2.7E-13								Y
				Y-90	2.7E-10	1.0E-03						2.7E-13								Y
Building 255 is operated by Hazards Control and houses a radiation calibration and standards laboratory. Many operations involve the use of sealed sources.																				
255	165	FHE-4	Analysis of urine for radionuclides	Am-241	8.6E-14	1.0E-03	6.9	0.30	5.1	None	1	8.6E-17	1056	E	9.4E-11	856	WSW	2.3E-10	1	Y
				Am-243	2.5E-12	1.0E-03						2.5E-15								Y
				C-14	3.5E-11	1.0E-03						3.5E-14								Y
				Cf-252	8.4E-12	1.0E-03						8.4E-15								Y
				Cm-242	9.1E-13	1.0E-03						9.1E-16								Y
				I-125	1.7E-10	1.0E-03						1.7E-13								Y
				Np-237	1.1E-10	1.0E-03						1.1E-13								Y
				Np-239	1.1E-10	1.0E-03						1.1E-13								Y
				P-32	2.8E-09	1.0E-03						2.8E-12								Y
				Pu-239	2.3E-13	1.0E-03						2.3E-16								Y
				Pu-242	1.4E-12	1.0E-03						1.4E-15								Y
				S-35	1.2E-10	1.0E-03						1.2E-13								Y
				Sr-90	4.9E-14	1.0E-03						4.9E-17								Y
				Th-230	9.4E-12	1.0E-03						9.4E-15								Y
				U-233	2.9E-14	1.0E-03						2.9E-17								Y
				U-234	1.1E-12	1.0E-03						1.1E-15								Y
				U-235	2.9E-14	1.0E-03						2.9E-17								Y
				U-236	8.7E-10	1.0E-03						8.7E-13								Y
				U-238	2.7E-15	1.0E-03						2.7E-18								Y
				Y-90	4.9E-14	1.0E-03						4.9E-17								Y
255	180	FHE-2	H-3 gas monitor calibrations	H-3	2.5E-02	1.0E+00	8.1	0.31	5.2	None	1	2.5E-02	1056	E	1.0E-05	1156	NNE	2.3E-05	2	Y
Trailer 2581 is operated by Hazards Control and had no operations in CY94.																				
2581	All	None	No Operations	None	None	NA	3.1	0.24	5.0	HEPA	0.01	0.0E+00	1104	E	0.0E+00	NA	NA	0.0E+00	2	Y
Building 281 is part of the Chemistry and Materials Sciences Directorate. In rooms 1311 and 1319, there are a number of sources, both as solids and in solution, which are kept and used in glove boxes. There are HEPA filters between the glove boxes and the vent stack. Room 1323 is used for collection of Nuclear Test Site groundwater samples. These samples contain some tritiated water.																				
281	1164	FHE-22	Solution chemistry of the actinides	Pu-242	3.7E-07	1.0E-03	6.7	0.30	7.1	Double HEPA	0.0001	3.7E-14	1332	ESE	4.1E-12	579	NNE	9.2E-07	2	Y
				Am-241	3.7E-07	1.0E-03						3.7E-14								Y
281	1174	FHE-13	Synthesis of expanded porphrins with actinides	U-238	4.0E-11	1.0E-03	6.7	0.30	6.1	None	1	4.0E-14	1332	ESE	1.1E-12	579	NNE	2.3E-11	2	Y
				Th-232	1.0E-11	1.0E-03						1.0E-14								Y
281	1184	Room Air	No Operations	None	None	NA	NA	NA	NA	None	1	0.0E+00	1332	ESE	0.0E+00	NA	NA	0.0E+00	2	Y
281	1307	FHE-6	Sample preparation for Ni-59 and Ni-63	Ni-59	3.5E-13	1.0E-03	6.4	0.61	2.7	HEPA	0.01	3.5E-18	1332	ESE	3.2E-14	579	NNE	3.4E-11	1	Y
				Ni-63	1.0E-06	1.0E-03						1.0E-11								Y
281	1311	FHE-12	Wet Chemistry Laboratory	U-233	4.5E-11	1.0E-03	6.1	0.41	4.0	None	1	4.5E-14	1332	ESE	9.5E-13	579	NNE	1.8E-11	2	Y
281	1311A	FHE-3	Wet Chemistry Laboratory	Th-232	2.5E-10	1.0E-03	4.9	0.25	10.3	None	1	2.5E-13	1332	ESE	5.0E-10	579	NNE	1.0E-08	2	Y
				Pu-242	1.0E-08	1.0E-03						1.0E-11								Y
281	1311B	FHE-3	Wet Chemistry Laboratory	Pu-242	4.0E-08	1.0E-03	4.9	0.25	10.3	Double HEPA	0.0001	4.0E-15	1332	ESE	1.9E-13	579	NNE	4.0E-08	2	Y
281	1314	FHE-9	Experimental Laboratory with Glove Boxes	Pu-242	2.0E-08	1.0E-03	5.9	0.41	2.5	Double HEPA	0.0001	2.0E-15	1332	ESE	1.3E-13	579	NNE	2.2E-08	2	Y
				U-233	1.0E-09	1.0E-03						1.0E-16								Y
281	1319	FHE-1	Experimental Laboratory with Glove Boxes	Th-232	3.0E-10	1.0E-03	5.2	0.28	9.2	Double HEPA	0.0001	3.0E-17	1332	ESE	4.8E-10	579	NNE	1.0E-04	2	Y
				Np-237	7.0E-05	1.0E-03						7.0E-12								Y
				Pu-242	5.0E-07	1.0E-03						5.0E-14								Y
Building 282 is operated by the Isotope Sciences Division of the Chemistry and Material Sciences Directorate. Experimental work involves neutrino particle mass and related studies. Gaseous tritium is absorbed on a "getter" material to which it is tightly bound at room temperature.																				
282	1000	Room Air	No Operations	None	None	NA	NA	NA	NA	HEPA	0.01	0.0E+00	1332	ESE	0.0E+00	NA	NA	0.0E+00	2	Y
Building 292 is administered by the Physics and Space Technologies Directorate. Residual contamination exists throughout the facility from the past operation of a rotating target neutron source, that is no longer in operation. Also, neutrino mass experiments have not been conducted since 1993.																				
292	1200/1202	Room Air	No Operations	H-3	1.8E+00	1.0E-03	NA	NA	NA	None	1	1.8E-03	1380	ESE	5.7E-07	493	NNE	1.3E-05	2	Y
292	1204	Room Air	No Operations	H-3	2.3E+01	1.0E-03	NA	NA	NA	None	1	2.3E-02	1380	ESE	7.3E-06	493	NNE	1.7E-04	2	Y
292	1402, 1402A 1404, 1406 1407	Room Air	No Operations	H-3	1.8E+00	1.0E-03	NA	NA	NA	None	1	1.8E-03	1380	ESE	5.7E-07	493	NNE	1.3E-05	2	Y
Building 298 is part of the Laser Fusion Program. Small amounts of tritium are used in this facility in conjunction with fusion target research and development.																				
298	189	FHE-14	Laser fusion target research and development	U-238	5.0E-10	1.0E-06	6.4	0.63	15.1	HEPA	0.01	5.0E-18	1398	SE	3.3E-17	344	NE	3.2E-13	2	Y
298	Various	Room Air	Laser fusion target research and development	H-3	3.0E-02	1.0E+00	NA	NA	NA	None	1	3.0E-02	1398	SE	1.3E-05	264	NNE	5.6E-04	2	Y
Buildings 321, 321A, 321B, and 321C are the Material Fabrication Shops and are part of the Mechanical Engineering Department. Operations in this complex include milling, shaping and machining of depleted uranium. Uranium pieces may be worked on in a single location, or may be moved from machine to machine. In addition, depleted uranium parts occasionally undergo heat treatment. The amount of depleted uranium that is handled depends on programmatic demands and varies from month to month. NOTE: Machining only occurs in 321C.																				

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category	Below App. E Quantity
321A	1001A	FHE-24	No Operations	None	None	NA	9.8	0.46	5.8	HEPA	0.01	0.0E+00	1032	ENE	0.0E+00	NA	NA	0.0E+00	2	Y
321C	1153	FHE-9	Forming	U-238	5.8E-01	1.0E-06	8.5	0.31	16.1	HEPA	0.01	5.8E-09	1032	ENE	4.2E-07	326	SW	1.7E-04	2	Y
321C	1351	FEV-1000	Machining and Manufacturing	U-238	5.8E-01	1.0E-06	12.5	0.60	6.0	HEPA	0.01	5.8E-09	1032	ENE	4.0E-07	326	SW	1.4E-04	2	Y
321C	1437	FHE-15	Machining and Manufacturing	U-238	5.8E-01	1.0E-06	11.2	0.23	13.4	HEPA	0.01	5.8E-09	1032	ENE	4.2E-07	326	SW	1.6E-04	2	Y
321C	1437A	FHE-11	Machining and Manufacturing	U-238	5.8E-01	1.0E-06	11.3	0.83	6.5	HEPA	0.01	5.8E-09	1032	ENE	4.0E-07	326	SW	1.3E-04	2	Y
Building 322 is operated by the Mechanical Engineering Department.																				
322	109	FHE-1	Cleaning and plating	U-234	6.0E-05	1.0E-06	7.9	0.35	1.0	None	1	6.0E-11	930	ENE	8.0E-09	316	SSW	2.5E-08	1	Y
			of depleted uranium	U-235	7.7E-07	1.0E-06					1	7.7E-13								Y
				U-238	5.5E-06	1.0E-06					1	5.5E-12								Y
Building 327 is operated by the Mechanical Engineering Department.																				
327	1275	Room Air	Non-destructive ultrasonic	U-234	8.0E-10	1.0E-03	NA	NA	NA	None	1	8.0E-13	1018	ENE	1.3E-09	425	SW	6.7E-09	1	Y
			material evaluation	U-235	1.1E-10	1.0E-03					1	1.1E-13								Y
				U-238	8.6E-09	1.0E-03					1	8.6E-12								Y
Building 331 is operated by the Defense and Nuclear Technologies Directorate. The building houses the tritium research facility and associated laboratories. The facility is undergoing significant reduction in tritium work and inventory down sizing.																				
*Tritium HT and HTO emissions are continuously monitored from the two 30 meter tall stacks in compliance with NESHAPs regulations. Monitoring data, rather than the inventory approach, are used to determine emissions.																				
**Stack emissions have been combined as permitted by the EPA/DOE Memorandum of Understanding.																				
331	All**	Stack 1	Tritium R&D; Decontamination	H-3	*	1.0E+00	30.0	1.22	7.6	None	1	5.9E+00	957	ENE	1.7E-02	1384	NE	1.7E-02	3	N/A
		Stack 2	and Decommissioning of Facility	H-3	*	1.0E+00	30.0	1.22	10.5	None	1	5.7E+01								
Building 332 is operated by the Defense Sciences Program for plutonium research. Exhausts from glove box operations and the workplace are triply filtered by high efficiency particulate air (HEPA) filters. Exhausts are monitored with both continuous filter sampling (PAMs) and plutonium-specific, continuous real-time monitors (CAMs). *Because building plutonium inventory and the plutonium associated with specific tasks is classified, the standard NESHAPs approach, based on inventory, cannot be utilized without classifying this report. The air monitoring data for all emission points show no detectable released plutonium activity, i.e. at or below the limit of sensitivity of the analytical analysis. **Because monitoring takes place after HEPA filtration, an unabated EDE cannot be determined (see discussion on page 40.)																				
332	Increment 1 Rooms	FHE-1000/2000	Plutonium research	Transuranics	*	NA	8.8	0.8x1.1	17.3	Triple HEPA	0.000001	0.0E+00	912	ENE	0.0E+00	* *	* *	* *	3	N/A
332	Increment 1 Glove boxes	FGBE-1000/2000	Plutonium research	Transuranics	*	NA	11	0.3	6.9	Triple HEPA	0.000001	0.0E+00	912	ENE	0.0E+00	* *	* *	* *	3	N/A
332	Downdraft	FHE-4/5	Plutonium research	Transuranics	*	NA	11	0.2	14.2	Double HEPA	0.0001	0.0E+00	912	ENE	0.0E+00	* *	* *	* *	3	N/A
332	Loft	FE-4	Plutonium research	Transuranics	*	NA	11	0.6x0.9	4.6	Triple HEPA	0.000001	0.0E+00	912	ENE	0.0E+00	* *	* *	* *	3	N/A
		FE-5	Plutonium research	Transuranics	*	NA	11	0.6x0.9	4.6	Triple HEPA	0.000001	0.0E+00	912	ENE	0.0E+00	* *	* *	* *	3	N/A
332	Increment 1 Glove boxes	FGBE-3000/4000	Plutonium research	Transuranics	*	NA	11	0.3	2	Triple HEPA	0.000001	0.0E+00	912	ENE	0.0E+00	* *	* *	* *	3	N/A
332	Increment 3 Room and Glove boxes	FFE-1000/2000 FGBE-7000/8000	Plutonium research	Transuranics	*	NA	10.1	0.9	12.2	Triple HEPA	0.000001	0.0E+00	912	ENE	0.0E+00	* *	* *	* *	3	N/A
Building 341 is a Physics and Space Technologies Directorate research facility. The experimental studies within the facility include the use of high-energy electrical systems, explosives, high-velocity armor impact experiments, and development and testing of optics, laser systems, flash x-ray generators, and hydro-diagnostics equipment.																				
341	1015	None	Storage for D-38 (DU) components	None	None	NA	10.0	0.40	8.0	None	1	0.0E+00	870	E	0.0E+00	NA	NA	0.0E+00	2	Y
The research complex for the Biology and Biotechnology Research Directorate includes buildings 361, 362, 363, 364, 365 and 366. Buildings 363 and 366 have discontinued the use of radionuclides. Building 365 contains small amounts of tritium, carbon-14 and sulfur-35 incorporated in animal carcases stored frozen pending disposal. No chemical operations are done in Building 365, and the building air is filtered through at least two HEPA filters and one charcoal filter before being exhausted. Most of the organs that contained radionuclides have been removed from the animals for examination. The radionuclide sources in building 361 include tritium, carbon-14, phosphorous-32, and sulfur-35, mostly incorporated as constituent atoms (tracers) in organic compounds.																				
361	1014	FHE-4	DNA Labeling and Sequencing	P-32	3.0E-03	1.0E-03	1.7	0.41	0.5	None	1	3.0E-06	918	ESE	7.8E-08	976	W	4.1E-07	2	Y
361	1020	FHE-5	DNA Hybridization	P-32	3.0E-03	1.0E-03	1.7	0.41	0.5	None	1	3.0E-06	918	ESE	7.8E-08	976	W	4.1E-07	2	Y
361	1242	FHE-24	Phosphorus 32 Labeling	P-32	3.5E-03	1.0E-03	1.7	0.41	0.5	None	1	3.5E-06	918	ESE	9.1E-08	976	W	4.8E-07	2	Y
361	1245	FHE-20,21	Human Genome	P-32	4.0E-02	1.0E-03	1.7	0.41	0.5	None	1	4.0E-05	918	ESE	1.1E-06	976	W	5.6E-06	2	Y
				S-35	2.0E-03	1.0E-03						2.0E-06								Y
361	1342	FHE-18	Enzyme Assay	C-14	1.0E-03	1.0E-03	7.0	0.41	4.4	None	1	1.0E-06	918	ESE	8.5E-09	953	NNE	6.9E-08	2	Y
361	1345	Room Air	DNA Labeling and Hybridization	P-32	2.0E-02	1.0E-03	NA	NA	NA	None	1	2.0E-05	918	ESE	4.7E-07	976	W	2.5E-06	2	Y
361	1346	FHE-17	No Operations	None	None	NA	7.0	0.41	4.4	None	1	0.0E+00	918	ESE	0.0E+00	NA	NA	0.0E+00	2	Y
361	1347	FHE-16	DNA Labeling and Hybridization	P-32	2.0E-02	1.0E-03	1.7	0.41	0.5	None	1	2.0E-05	918	ESE	5.2E-07	976	W	2.7E-06	2	Y
361	1442	FHE-31	No Operations	None	None	NA	7.3	0.26	3.6	None	1	0.0E+00	918	ESE	0.0E+00	NA	NA	0.0E+00	2	Y
361	1445	FHE-14	DNA Repair and Chromatin	P-33	1.0E-03	1.0E-03	1.7	0.41	0.4	None	1	1.0E-06	918	ESE	1.2E-07	976	W	6.3E-07	2	Y
				S-35	1.0E-02	1.0E-03						1.0E-05								
361	1446	FHE-15	No Operations	None	None	NA	7.0	0.41	4.4	None	1	0.0E+00	918	ESE	0.0E+00	NA	NA	0.0E+00	2	Y
361	1542	FHE-12	DNA Labeling	P-32	6.0E-03	1.0E-03	7.0	0.41	4.4	None	1	6.0E-06	918	ESE	5.7E-08	953	NNE	4.4E-07	2	Y

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category	Below App. E Quantity
				S-35	0.0E+00	1.0E-03						0.0E+00								
361	1546	FHE-10	DNA Labeling	P-32	4.0E-03	1.0E-03	1.7	0.41	0.5	None	1	4.0E-06	918	ESE	1.0E-07	976	W	5.5E-07	2	Y
361	1564	FHE-2000	No Operations	None	None	NA	7.6	0.65	5.6	None	1	0.0E+00	918	ESE	0.0E+00	NA	NA	0.0E+00	2	Y
361	1568	FHE-2000	Biological Dosimetry	P-32	4.5E-04	1.0E-03	1.7	0.41	0.4	None	1	4.5E-07	918	ESE	1.5E-08	976	W	7.8E-08	2	Y
				P-33	1.2E-04	1.0E-03						1.2E-07								
361	1635	Room Air	DNA Sequencing	P-32	2.0E-04	1.0E-03	NA	NA	NA	None	1	2.0E-07	918	ESE	4.7E-09	976	W	2.5E-08	2	Y
361	1642	FHE-11	DNA/RNA Hybridization	P-32	1.0E-03	1.0E-03	7.0	0.41	4.4	None	1	1.0E-06	918	ESE	9.6E-09	953	NNE	7.4E-08	2	Y
361	1649	FHE-4	Biological Dosimetry	P-33	3.0E-03	1.0E-03	7.0	0.41	4.4	None	1	3.0E-06	918	ESE	7.5E-08	976	W	4.0E-07	2	Y
				S-35	5.0E-04	1.0E-03						5.0E-07								Y
361	1658	FHE-1000	No Operations	None	None	NA	7.6	0.65	2.8	None	1	0.0E+00	918	ESE	0.0E+00	NA	NA	0.0E+00	2	Y
361	1658C	FHE-1000	Radioactive Probes	P-32	8.8E-03	1.0E-03	7.6	0.65	2.8	None	1	8.8E-06	918	ESE	2.3E-07	976	W	1.2E-06	2	Y
361	1664	FHE-2000	Human Genome	None	None	NA	7.0	0.41	4.4	None	1	0.0E+00	918	ESE	0.0E+00	NA	NA	0.0E+00	2	Y
361	1742	FHE-8	Biological Dosimetry	P-32	2.0E-02	1.0E-03	7.0	0.41	4.4	None	1	2.0E-05	918	ESE	5.2E-07	976	W	2.7E-06	2	Y
361	1745	FHE-7	No Operations	None	None	NA	7.0	0.41	4.4	None	1	0.0E+00	918	ESE	0.0E+00	NA	NA	0.0E+00	2	Y
361	1846	Room Air	Human Genome	P-32	4.0E-02	1.0E-03	NA	NA	NA	None	1	4.0E-05	918	ESE	9.6E-07	976	W	5.1E-06	2	Y
				S-35	2.0E-03	1.0E-03						2.0E-06								Y
Building 362																				
362	113	Room Air	Dose Preparation	C-14	1.0E-03	1.0E-03	NA	NA	NA	None	1	1.0E-06	990	ESE	2.2E-08	885	W	1.5E-07	2	Y
Building 363																				
363	1009	FHE-2000	Dispensing Samples	H-3	3.6E-02	1.0E-03	1.7	0.41	0.4	HEPA	1	3.6E-05	996	ESE	1.9E-06	892	W	1.5E-07	2	Y
Building 364																				
364	1507	Room Air	DNA Labeling	P-32	3.0E-01	1.0E-03	NA	NA	NA	None	1	3.0E-04	996	ESE	6.3E-06	904	W	4.2E-05	2	Y
364	1519	Room Air	Isolation and Purification	C-14	5.0E-04	1.0E-03	NA	NA	NA	None	1	5.0E-07	996	ESE	1.1E-08	904	W	7.4E-08	2	Y
Building 365																				
365	109	FHE-5	Research Animals Housed	C-14	1.3E-04	1.0E-03	1.7	0.41	0.6	Double HEPA	0.0001	1.3E-11	1002	ESE	6.4E-13	902	W	2.9E-08	2	Y
				H-3	5.0E-07	1.0E-03					1	5.0E-10								Y
Building 366																				
366	103	FHE-1	Metabolism Heterocyclic Amines	H-3	4.0E-03	1.0E-03	1.7	0.41	0.5	None	1	4.0E-06	912	ESE	2.5E-09	998	W	1.4E-08	2	Y
366	111	FHE-1	DNA Sequencing	P-33	5.0E-04	1.0E-03	1.7	0.41	0.4	Biocabinet/HEPA	0.01	5.0E-09	912	ESE	1.3E-10	998	W	6.4E-08	2	Y
Building 377 is operated by the Health and Ecological Assesssment Division. Activities in this facility were associated with chemical and radiological sample preparation for environmental analysis, and analysis of soil, water, vegetation, etc., samples.																				
377	1003	Stack FHE-6 removed	No Operations	None	None	NA	NA	NA	NA	None	1	0.0E+00	1005	ESE	0.0E+00	NA	NA	0.0E+00	2	Y
377	1005	Stack FHE-1 removed	No Operations	None	None	NA	NA	NA	NA	None	1	0.0E+00	1005	ESE	0.0E+00	NA	NA	0.0E+00	2	Y
377	1028	FHE-1000	No Operations	None	None	NA	8.2	0.23	20.6	None	1	0.0E+00	1005	ESE	0.0E+00	NA	NA	0.0E+00	2	Y
Building 378 is operated by the Health and Ecological Assessment Division. The major activities in this facility are associated with chemical and radiological sample preparation for environmental analysis, and analysis of soil, water, vegetation, etc., samples.																				
378	120	378-120-FHE-1,2,3,4,5,8,9,10	Environmental analysis	Am-241	7.2E-10	1.0E-03	8.5	0.30	5.9	None	1	7.2E-13	888	ESE	1.5E-10	857	NNE	1.5E-09	2	Y
				Pu-236	3.6E-10	1.0E-03						3.6E-13								Y
				Pu-242	1.8E-09	1.0E-03						1.8E-12								Y
378	120	378-120-FHE-6,7	Environmental analysis	Am-241	1.8E-10	1.0E-03	8.5	0.30	9.7	None	1	1.8E-13	888	ESE	3.3E-11	857	NNE	3.6E-10	2	Y
				Pu-236	9.0E-11	1.0E-03						9.0E-14								Y
				Pu-242	4.5E-10	1.0E-03						4.5E-13								Y
Building 381 is part of the Laser Fusion Program. Small quantities of tritium are handled in support of laser target research and development.																				
381	B156	381-B156-FHE-1	Tritium handling for laser target R&D	H-3	4.0E-04	1.0E-06	11.3	0.36	20.6	None	1	4.0E-04	1092	SE	2.7E-14	560	NNE	6.9E-07	2	Y
Building 391 is part of the Laser Fusion Program. The high energy laser is located in this facility. Small amounts of tritium are handled in support of laser target research and development.																				
391	Target Chamber	391-FHE-1	Fusion Target Irradiation Area	H-3	2.1E-01	1.0E+00	6.1	0.30	9.9	None	1	2.1E-01	1149	SE	2.8E-05	403	NNE	9.0E-04	2	Y
Building 412W R1110 was used by the Health and Ecological Assessment Division for approximately 6 months in 1995.																				
412W	1110	412W-1110-FHE	Sample preparation for measurement of Ni-59 and Ni-63	Ni-59	3.5E-13	1.0E-03	11.5	0.25	4.4	HEPA	0.01	3.5E-18	702	NE	2.3E-13	158	SSW	5.0E-11	1	Y
				Ni-63	1.0E-06	1.0E-03					0.01	1.0E-11								Y
Building 419 has been used previously for the decontamination of equipment. However, it is now undergoing closure.																				
*Exhausts from the facility are continuously sampled; measured emissions, rather than the inventory approach are used to determine annual emissions.																				
**Because monitoring takes place after HEPA filtration, an unabated EDE cannot be determined (see discussion on page 40.)																				
419	124	FHE-2	Decontamination acitivities	Gross alpha	*	NA	12.2	0.61	12.6	Double HEPA	0.0001	1.5E-07	686	NE	9.8E-05	* *	* *	* *	3	N/A

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category	Below App. E Quantity
				Gross beta	*							1.4E-06								
419	155	FHE-6	Decontamination acitivities	Gross alpha	*	NA	11	0.76	5.4	HEPA	0.01	8.4E-08	686	NE	6.1E-05	* *	* *	* *	3	N/A
				Gross beta	*							9.0E-07								

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category	Below App. E Quantity
Building 490 & 491 are part of LLNL's Uranium Atomic Vapor Laser Isotope Separation (U-AVLIS) program, now affiliated with The United States Enrichment Corporation (USEC). The Separator Demonstration Facility (SDF), which vaporizes uranium for enrichment, is located in building 490. Stack sampling at both facilities is continuous. Both facilities operate with two in-series high efficiency particulate (HEPA) filter banks to control emissions.																				
*Air emissions are continuously sampled at the post-HEPA-filter atmospheric discharge points, although emissions are low enough that stack monitoring is not required per the NESHAPs 40 CFR 61 regulations.																				
**Because monitoring takes place after HEPA filtration, an unabated EDE cannot be determined (see discussion on page 40.)																				
490	1061	490 Stack	Isotope Separation	Gross alpha	*	NA	9.1	0.90	5.7	Double HEPA	0.0001	0.0E+00	900	SE	0.0E+00	* *	* *	* *	3	N/A
				Gross beta	*							0.0E+00								
Building 491																				
491	All	FFE-1	Isotope Separation	Gross alpha	*	NA	9.1	0.9	12.1	Double HEPA	0.0001	0.0E+00	1000	SSE	0.0E+00	* *	* *	* *	3	N/A
				Gross beta	*							0.0E+00								
Building 513 is operated by the Hazardous Waste Management Division. The Stabilization Unit is a mechanized mixing device used to make homogeneous mixtures of waste. Solidification agents are added during mixing to transfer sludges to solids. The Microfiltration Unit filters out waste radioactive particles. In the Laboratory, small quanities of waste materials are sampled, treated, and stored. No releases are assumed to occur from waste storage because the wastes are fully contained.																				
513	Stabilization	Room Air	Stabilizes sludges to solids	U-238	7.5E-05	1.0E-06	NA	NA	NA	None	1	7.5E-11	579	NE	3.8E-08	128	SW	2.0E-07	1	Y
			Drum repacking	U-235	9.8E-07	1.0E-06						9.8E-13				and				Y
				U-234	7.0E-06	1.0E-06						7.0E-12				98	SSW			Y
513	Microfiltration	Room Air	No Operations	None	0.0E+00	NA	NA	NA	NA	None	1	0.0E+00	579	NNE	0.0E+00	128	SW	0.0E+00	1	Y
513	Laboratory	513 Stack	No Operations	None	0.0E+00	NA	8.6	0.32	8.0	HEPA	0.01	0.0E+00	579	NE	0.0E+00	128	SW	0.0E+00	1	Y
Building 514 - See Diffuse Sources Section below.																				
SITE 300 POINT SOURCES																				
Site 300 - Explosives tests are conducted on open-air firing tables located at Bunkers 801, 850, and 851. These tests have depleted uranium material as part of the material inventory. There are multiple tests per year. A total for 1995 is shown here. The radionuclides in Buildings 804, 810A, 810B, 822B, and 854F are encapsulated or sealed and are not used.																				
801	Firing Table	None	Explosive tests	U-238	3.5E-02	1.0E+00	NA	NA	NA	None	1	3.5E-02	2380	ESE	1.2E-02	1809	ENE	1.9E-02	4	N
				U-235	4.5E-04	1.0E+00						4.5E-04								N
				U-234	3.2E-03	1.0E+00						3.2E-03								N
850	Firing Table	None	No Operations	None	None	NA	NA	NA	NA	None	1	0.0E+00	4206	ESE	0.0E+00	NA	NA	0.0E+00	4	Y
851	Firing Table	None	Explosive tests	U-238	2.0E-02	1.0E+00	NA	NA	NA	None	1	2.0E-02	3870	E	8.2E-03	1396	WSW	1.8E-02	4	N
				U-235	2.6E-04	1.0E+00						2.6E-04								N
				U-234	1.9E-03	1.0E+00						1.9E-03								N
LIVERMORE SITE DIFFUSE SOURCES																				
Building 292 - Diffuse emissions result from tritium-contaminated water which leaked from an underground storage tank. Vegetation in the area transpires water with elevated tritium concentrations.																				
292	Spill Area	None	Evaporation and Transpiration	H-3	NA	1.0E+00	NA	NA	NA	None	1	4.8E-04	1390	ESE	1.3E-07	456	N	3.0E-06	6	Y
Building 331 - As part of D&D operations contaminated equipment outside the facility is awaiting transport and storage by Hazardous Waste Management.																				
331	Outside	None	Storage of Contaminated Parts	H-3	NA	1.0E+00	NA	NA	NA	None	1	4.0E+00	957	ENE	5.9E-03	573	SW	2.8E-02	6	Y
Building 419 - Pipe removal activity as part of tank project.																				
419	Outside	Area Source	Removal of contaminated soil	H-3	NA	1.0E+00	NA	NA	NA	None	1	2.2E-02	686	NE	4.6E-05	120	SSW	2.5E-04	5	Y
Building 514 is operated by the Hazardous Waste Management Division. The wastewater treatment tank farm and storage tank area processes the liquid waste from facilities on site. The treatment process may involve batch chemical treatment consisting of neutralization, floculation, oxidation, reduction, precipitation, separation, and filtration. Areas used for storage are not considered to release radionuclides because the wastes are fully contained.																				
514	Tank Farm	Area Source	Processes liquid hazardous	Am-241	7.3E-05	1.0E-03	NA	NA	NA	None	1	7.3E-08	530	NE	7.2E-04	217	SW	1.8E-03	5	Y
			mixed and radioactive wastes in	Am-243	2.2E-06	1.0E-03						2.2E-09				and				Y
			open topped tanks.	C-14	1.2E-04	1.0E-03						1.2E-07				167	SSW	1.8E-03		Y
				Co-60	2.6E-06	1.0E-03						2.6E-09								Y
				Ce-144	3.6E-07	1.0E-03						3.6E-10								Y
				Cs-134	6.0E-09	1.0E-03						6.0E-12								Y
				Cs-137	1.4E-04	1.0E-03						1.4E-07								Y
				Eu-152	1.8E-04	1.0E-03						1.8E-07								Y
				Eu-154	9.1E-05	1.0E-03						9.1E-08								Y
				Eu-155	6.9E-06	1.0E-03						6.9E-09								Y
				Eu-156	1.7E-07	1.0E-03						1.7E-10								Y
				H-3	5.4E-03	1.0E-03						5.4E-06								Y
514	(continued)			K-40	1.0E-06	1.0E-03						1.0E-09								Y
				Mn-54	5.9E-08	1.0E-03						5.9E-11								Y
				Np-237	1.3E-05	1.0E-03						1.3E-08								Y
				P-32	3.7E-02	1.0E-03						3.7E-05								Y
				Pu-238	1.0E-05	1.0E-03						1.0E-08								Y
				Pu-239	1.0E-06	1.0E-03						1.0E-09								Y
				Pu-242	1.1E-05	1.0E-03						1.1E-08								Y
				Ra-226	2.8E-07	1.0E-03						2.8E-10								Y
				Ru-106	2.9E-06	1.0E-03						2.9E-09								Y
				S-35	4.2E-03	1.0E-03						4.2E-06								Y
				Sb-125	4.6E-08	1.0E-03						4.6E-11								Y
				Sr-90	5.3E-05	1.0E-03						5.3E-08								Y
				Tc-99	2.0E-06	1.0E-03						2.0E-09								Y
				Th-228	4.2E-05	1.0E-03						4.2E-08								Y
				U-233	1.0E-06	1.0E-03						1.0E-09								Y
				U-234	5.0E-05	1.0E-03						5.0E-08								Y

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category	Below App. E Quantity
				U-235	1.0E-05	1.0E-03						1.0E-08								Y
				U-238	6.6E-04	1.0E-03						6.6E-07								Y
The Building 612 Yard is operated by the Hazardous Waste Management Division. The Yard consists of several areas where containers having radioactive wastes are stacked outdoors. The containers, which are not air tight, can outgas tritium.																				
612	Yard	Area Source	Storage of low level waste	H-3	2.1E+00	1.0E+00	NA	NA	NA	None	1	2.1E+00	420	NNE	1.4E-02	283	SW	4.1E-02	6	Y
The Southeast Quadrant of the Livermore Site has slightly elevated levels of Pu-239 in the surface soil and air (presumably from resuspension). The source of the Pu-239 was past waste management operations.																				
Southeast Quadrant		Area Source	Resuspension	Pu-239	NA	NA	NA	NA	NA	None	1	NA	0	NA	9.4E-04	NA	NA	NA	6	Y
SITE 300 DIFFUSE SOURCES																				
Diffuse sources consist of evapotranspiration of tritiated water and resuspension of depleted uranium. Tritiated water sources include land areas where water purged from wells has been dumped, an open artesian spring, and evaporation of water from soils due to migration from contaminated ground water.																				
Pit 7 complex		Area Source	Evaporation from Soil and purge water	H-3	9.2E-01	1.0E+00	NA	NA	NA	None	1	9.2E-01	4862	ESE	3.5E-05	853	NNE	7.1E-04	5	Y
802		Area Source	Evaporation from Soil	H-3	5.6E-04	1.0E+00	NA	NA	NA	None	1	5.6E-04	2380	ESE	6.2E-08	1423	NNE	1.8E-07	5	Y
850		Area Source	Evaporation from Soil	H-3	1.1E-01	1.0E+00	NA	NA	NA	None	1	1.1E-01	4206	E	6.2E-06	1496	NNE	3.3E-05	5	Y
851		Area Source	Evaporation from Soil	H-3	3.3E-04	1.0E+00	NA	NA	NA	None	1	3.3E-04	3870	E	2.1E-08	1386	WNW	5.4E-08	5	Y
Well 8 Spring		Area Source	Evaporation from Spring Water	H-3	2.3E-03	1.0E+00	NA	NA	NA	None	1	2.3E-03	4084	E	1.4E-07	732	N	1.5E-06	5	Y
Site 300	All	Area Source	Soil Resuspension	U-238	NA	NA	NA	NA	NA	None	1	NA	0	NA	2.6E-03	NA	NA	NA	6	Y
				U-235	NA	NA						NA								Y
				U-234	NA	NA						NA								Y

Attachment 2. Surrogate Radionuclides List

Although CAP88-PC supports calculations for many radionuclides, there are some in use at LLNL that are not included in CAP88-PC. Consequently, this list of surrogate radionuclides has been developed to account for the contribution of those radionuclides.

Table 2-1. List of surrogate radionuclides.

Radionuclide	Half-life	Lung Class[a]	ALI (inh), μCi	DAC, μCi/cm^3	Surrogate	Correction Factor[b]
^{108m}Ag	127 y	Y	20	1×10^{-8}	^{60}Co	
^{207}Bi	38 y	W	400	1×10^{-7}	^{214}Bi	
^{45}Ca	163 d	W	800	4×10^{-7}	^{90}Sr	
^{109}Cd	464 d	D	40	1×10^{-8}	^{60}Co	
^{249}Cf	351 y	Y	0.01	4×10^{-12}	^{241}Am	
^{250}Cf	13.1 y	W	0.009	4×10^{-12}	^{241}Am	
^{36}Cl	3.01×10^5 y	W	200	1×10^{-7}	^{137}Cs	
^{254}Es	276 d	W	0.07	3×10^{-11}	^{239}Pu	
^{149}Eu	93.1 d	W	3000	1×10^{-6}	^{156}Eu	
^{148}Gd	93 y	D	0.008	3×10^{-12}	^{140}La	1×10^5
^{185}Os	94 d	D	500	2×10^{-7}	^{99}Mo	
^{33}P	25.4 d	D	8000	4×10^{-6}	^{32}P	
^{184}Re	38.0 d	W	1000	6×10^{-7}	^{99}Mo	
^{75}Se	120 d	W	600	3×10^{-7}	^{32}P	
^{85}Sr	64.8 d	Y	2000	6×10^{-7}	^{90}Sr	
^{182}Ta	115 d	Y	100	6×10^{-8}	^{99}Mo	
^{157}Tb	150 y	W	300	1×10^{-7}	^{140}La	
^{158}Tb	150 y	W	20	8×10^{-9}	^{140}La	50
^{204}Tl	3.78 y	D	2000	9×10^{-7}	^{214}Pb	
^{168}Tm[c]	85 d	W	2000	8×10^{-7}	^{140}La	
^{171}Tm	1.92 y	W	300	1×10^{-7}	^{140}La	5

a D = days, W = weeks, Y = years.

b The annual inventory is multiplied by the correction factor, and a resulting surrogate equivalency is used for the modeling calculation.

Source: Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion and Ingestion, Federal Guidance Report No. 11, EPA-520/1-88-020, U.S. Environmental Protection Agency, 1988.

Attachment 3. Dose Calculations for Tritium

Tritium is one of the largest contributors to the dose to the Maximally Exposed Individual (MEI) for the LLNL Main Site. Consequently, it is important to understand the effects that the defaults assumed in CAP88-PC have on the dose calculations for this radionuclide. The inhalation dose calculation is very straightforward for all radionuclides. Fortunately, the ingestion dose from tritium is handled as a special case in CAP88-PC, and these calculations are easy to follow, as well. Unfortunately, the actual implementation of the equations is not exactly what is documented.

The User Guide for CAP88-PC does not include the dose equations that are implemented in the model. These equations are found in the AIRDOS manuals, upon which the dosimetry of the CAP88-PC model is based.

The calculation of dose begins with the calculation of the concentration of tritium in air at the location of interest, i.e., the MEI. CAP88-PC calculates χ/Q (in sec/m^3) using a Gaussian plume dispersion model. The total emission from a source is multiplied by the χ/Q to yield the concentration in air at the location of interest; χ/Q for the Livermore MEI using Building 331 as the source and 1995 meteorological data is 1.551×10^{-6} sec/m^3. The emission rate for this source was 63 Ci/y in 1995. The concentration, χ, in pCi/m in air at the MEI location equals

$$\chi = 63\frac{Ci}{y} \times 1.551 \times 10^{-6}\frac{\sec}{m^3} \times 3.17 \times 10^4 \frac{pCi/Ci}{\sec/y} \quad ,$$

$$\chi = 3.1\frac{pCi}{m^3} \quad ,$$

where 3.17×10^4 is a combined conversion factor for expressing Ci as pCi and years as seconds.

All doses in CAP88-PC are calculated for adults only. The inhalation dose from tritium is handled as follows.

$$Dose_{inh} = Annual\ Inhalation\ Rate\left(\frac{m^3}{y}\right) \times Air\ Concentration\left(\frac{pCi}{m^3}\right) \times Dose\ Conversion\ Factor\left(\frac{mrem}{pCi}\right)$$

$$Dose_{inh} = 0.917\frac{m^3}{h} \times 24\frac{h}{d} \times 365\frac{d}{y} \times 3.1\frac{pCi}{m^3} \times 1.263 \times 10^{-7}\frac{mrem}{pCi}$$

$$Dose_{inh} = 3.14 \times 10^{-3}\frac{mrem}{y}\ .$$

The dose conversion factor of 1.263×10^{-7} mrem/pCi is nearly double the inhalation conversion factor of 6.4×10^{-8} mrem/pCi stated in Federal Guidance Report No. 11, "Limiting Values of Radionuclide Intake And Air Concentration and Dose Conversion Factors For Inhalation, Submersion, And Ingestion," (EPA 520/1-88-020, 1988), and is based on the ICRP 2 (Report of Committee II on Permissible Dose for Internal Radiation, International Commission on Radiological Protection, 1959) recommendation that skin intake equal the lung intake. ICRP 30 (Limits for Intakes of Radionuclides by Workers, International Commission on Radiological Protection, 1980) contains the recommendation that skin intake should be 50% of the lung intake. (If more current ICRP recommendations were used, the inhalation dose would be 2.39×10^{-3} mrem/y.)

For ingestion doses, CAP88-PC follows the logic that tritium, because it exchanges hydrogen readily with water molecules in air, "may be assumed to follow water almost precisely through the environment." Consequently, the doses from ingestion of food and drinking water at a location are assumed to be in proportion to the concentration of tritium in air.

The total ingestion dose is equal to the sum of the dose for ingestion of vegetables, meat, milk, and water.

$$Dose_{ing} = Dose_{veg} + Dose_{meat} + Dose_{milk} + Dose_{water}\ .$$

These doses, in turn, are defined as follows:

$$Dose_{veg} = 0.505 \times C_f\left(f_{v1}\chi + f_{v2}\chi_v\right),$$

$$Dose_{meat} = 0.185 \times C_f\left(f_{m1}\chi + f_{m2}\chi_m\right),$$

$$Dose_{milk} = 0.310 \times C_f\left(f_{k1}\chi + f_{k2}\chi_k\right), \text{ and}$$

$$Dose_{water} = C_w \times \chi \times 0.01, \text{ where}$$

C_f is the dose conversion factor for food (rem-cm^3/pCi-year). It is derived based on the specific activity of tritium in atmospheric moisture with an average specific humidity of 8 grams of water per cubic meter of air. Using a total-body dose conversion factor of 8.993×10^{-5} rem/μCi (not 8.3×10^{-5} rem/μCi as stated in the AIRDOS manual [Steve Maheras, SAIC at INEL, personal communication, 1996]), assuming tritium in food is in equilibrium with atmospheric tritium, and that an adult consumes 1638 g/d of water in food, C_f is 6.4 rem-cm^3/pCi-year. The contribution to the food ingestion dose is 50.5% from vegetables, 18.5% from meat, and 31.0% from milk. "These percentages are based on approximate water contents of foods of 82.4% for vegetables, 62.3% for meat, and 87.5% for milk and for daily intakes of 0.532 kg of vegetables, 0.258 kg for meat, and 0.307 kg of milk." (AIRDOS-EPA: A Computerized Methodology for Estimating Environmental Concentrations and Dose to Man from Airborne Releases of Radionuclides, R.E. Moore, et al., EPA 520/1-79-009, 1979.)

C_w is the dose conversion factor for water. It is also derived based on the specific activity of tritium in atmospheric moisture with an average specific humidity of 8 grams of water per cubic meter of air. Using a total-body dose conversion factor of 8.3×10^{-5} rem/μCi, assuming tritium in water is in equilibrium with atmospheric tritium, and that an adult consumes 1512 g/d of water, C_f is 5.7 rem-cm^3/pCi-year. To account for dilution by distant sources of drinking water, a factor of 0.01 is applied.

χ is the ground-level concentration of tritium in air at the location (pCi/cm3). $\chi_{v,}$ $\chi_{m,}$ and χ_k are the average ground-level concentration of tritium in air over the assessment area weighted by the quantity of vegetables, meat, and milk, respectively, produced as a function of location.

f_{v1}, f_{m1}, and f_{k1}, are the fractions of vegetable, meat, and milk intake that are produced at the individuals environmental location, and f_{v2},

f_{m2}, and f_{k2} are the fractions of vegetable, meat, and milk intake for which the source is an average for the assessment area. (Note that neither f_{v1} and f_{v2}, nor f_{m1} and $f_{m2,}$ nor f_{k1} and f_{k2} need add up to 1 because the vegetables, meat, or milk could be imported from outside the region affected by the source.)

From these ingestion equations, it appears that the effects of assumptions about the location of the production of vegetables, meat, and milk, directly affects the dose calculated by CAP88-PC for tritium. The LLNL practice in previous years has been to assume that all vegetation, meat, and milk ingested by the MEI is produced locally, i.e., at the location of the MEI. This corresponds to f_{v1}, f_{m1}, and f_{k1}, all equaling 1.0. The assumption of one hundred percent local food production is not a reasonable assumption for the Livermore location. There are no local cow's milk dairies (nor have there been for nearly 20 years), and sale of locally produced goat's milk has ceased (see Environmental Report for 1993, Lawrence Livermore National Laboratory, 1994). Therefore, beginning with this 1995 NESHAPs report, the fraction of locally produced milk will be set to zero; all milk consumption will be treated as "imported" from outside the region. We will continue to use 1.0 as the factor for vegetation and meat for f_{v1}, f_{m1}, pending the identification of better factors for f_{v1}, f_{m1}, and f_{v2}, and f_{m2}.

The effect of this change in the assumption for milk ingestion on the ingestion dose to the MEI from emissions from Building 331 for 1995 is to reduce the dose from 2.0×10^{-2} to 1.4×10^{-2} mrem/year; the effect on total dose is to reduce it from 2.3×10^{-2} to 1.7×10^{-2} mrem/year.

Technical Information Department • **Lawrence Livermore National Laboratory**
University of California • Livermore, California 94551